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Yoga in Prevention and Therapy

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Editorial Board

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Editorial

Yoga in Prevention and Therapy

Holger Cramer,[1] Crystal L. Park,[2] Amie Steel,[3,4] Bangalore N. Gangadhar,[5] and Karen Pilkington[6]

[1]*Department of Internal and Integrative Medicine, Kliniken Essen-Mitte, Faculty of Medicine, University of Duisburg-Essen, Essen, Germany*
[2]*Department of Psychology, University of Connecticut, Storrs, CT, USA*
[3]*Endeavour College of Natural Health, Brisbane, QLD, Australia*
[4]*Australian Research Centre in Complementary and Integrative Medicine (ARCCIM), Faculty of Health, University of Technology Sydney, Sydney, NSW, Australia*
[5]*National Institute of Mental Health and Neurosciences, Bangalore, India*
[6]*School of Health Sciences and Social Work, University of Portsmouth, Portsmouth, UK*

Correspondence should be addressed to Holger Cramer; h.cramer@kliniken-essen-mitte.de

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Yoga is rooted in Indian philosophy and has been a part of traditional Indian spiritual practice for millennia [1]. In recent times, the role of yoga has broadened. Yoga has now also become a popular route to physical and mental well-being and has been adapted for use in complementary and integrative medicine internationally [2]. In the latter setting, yoga most often includes physical postures, breath control, deep relaxation, and meditation/mindfulness techniques. In Western societies, yoga is gaining increased popularity as a preventive and therapeutic practice, making it one of the therapies with the most rapid increase in prevalence [3].

As such, health-care providers are increasingly presented with patients using, or interested in trying, yoga for the management of their health conditions [4]. This increased use of yoga raises issues regarding the efficacy and safety of yoga as a health therapy. Moreover, the potential psychological and physiological mechanisms of action of yoga when used as a preventive and therapeutic modality remain largely unknown. Both efficacy and mechanisms need to be investigated in greater depth in order to inform clinical decision-making and improve research quality regarding one of the most frequently used complementary therapies.

This special issue is dedicated to research that focuses on the clinical application of yoga in preventive medicine and therapy. The peer-reviewed issue solicited original manuscripts in the field of yoga research with a focus on studies that investigated the therapeutic and/or preventive potential of this complementary health-care approach. The accepted manuscripts represent a broad range of research, including clinical trials, qualitative studies, and systematic reviews.

Most papers in this special issue addressed clinical questions and/or the implementation of yoga therapy in different settings. In a randomized controlled trial, Sohl et al. demonstrated beneficial effects of yoga combined with an evidence-based health education program compared to education alone in patients with metabolic syndrome. Positive effects of the combined treatment beyond education alone mainly occurred for physical aspects of quality of life. In a pilot trial, a ten-week yoga therapy intervention induced improvements in joint pain and anxiety in children with cystic fibrosis. This study is important not only because yoga research in pediatric populations is rare but also because it used a one-on-one therapeutic approach, which much more closely resembles the typical yoga therapy setting in clinical practice than the group sessions that are often used in clinical trials. Another study evaluated the feasibility of yoga in a rehabilitation and complex continuing care setting. This study found that yoga adapted for wheelchair users not only was feasible in this setting but also decreased anxiety and pain catastrophizing

while increasing self-compassion. Likewise, results of the "Yoga Empowers Seniors Study" demonstrated that yoga could improve physical function in community-dwelling older adults.

Beyond clinical research, this issue features two qualitative studies. Ross et al. interviewed twenty yoga practitioners (three-quarters of them being female) who intentionally or unintentionally had lost weight as a consequence of their yoga practice. They found that, besides physical and psychological changes brought about by yoga practice, changes in eating patterns were perceived as mechanisms of yoga for weight loss. The second qualitative study used focus groups of cancer survivors who had participated in an ongoing community-based yoga program specifically for this patient population. They found that patients valued this disease-specific approach and emphasized the shared understanding and the cancer-specific yoga instructions.

Finally, using a more methodologically oriented approach, a meta-analysis addressed drop-out rates in yoga trials. Based on 168 randomized trials, this analysis provides a guideline for expected drop-out rates when planning randomized controlled trials of yoga interventions.

Several issues remain to be investigated in further research. There are challenges in yoga research such as ideal placebo condition, double-blinding, generic forms of yoga, precise description of the procedure in a given study, and measurements of outcome. Yoga could offer benefits in several domains other than therapy and prevention. This too deserves attention.

We are confident that this special issue, covering a broad spectrum of yoga therapy research, advances the evidence base of this emerging field and usefully informs therapists, health-care providers, and researchers alike.

Holger Cramer
Crystal L. Park
Amie Steel
Bangalore N. Gangadhar
Karen Pilkington

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Research Article

Evaluation of a Specialized Yoga Program for Persons Admitted to a Complex Continuing Care Hospital: A Pilot Study

Kathryn Curtis,[1] Kerry Kuluski,[2,3] Gitte Bechsgaard,[4] Jennifer Ridgway,[5] and Joel Katz[1]

[1]*Department of Psychology, Faculty of Health, York University, 4700 Keele St., Toronto, ON, Canada M3J 1P3*
[2]*Lunenfeld-Tanenbaum Research Institute, Sinai Health System, 982-600 University Avenue, Toronto, ON, Canada M5G 1X5*
[3]*Institute of Health Policy, Management and Evaluation, University of Toronto, 4th Floor, 155 College St., Toronto, ON, Canada M5T 3M6*
[4]*Vidya Institute, 253 Christie St., Toronto, ON, Canada M6G 3B8*
[5]*Therapeutic Recreation, Sinai Health System-Bridgepoint Site, 1 Bridgepoint Drive, Toronto, ON, Canada M4M 2B5*

Correspondence should be addressed to Kathryn Curtis; kjbc@yorku.ca

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Introduction. The purpose of this study was to evaluate a specialized yoga intervention for inpatients in a rehabilitation and complex continuing care hospital. *Design*. Single-cohort repeated measures design. *Methods*. Participants ($N = 10$) admitted to a rehabilitation and complex continuing care hospital were recruited to participate in a 50–60 min Hatha Yoga class (modified for wheelchair users/seated position) once a week for eight weeks, with assigned homework practice. Questionnaires on pain (pain, pain interference, and pain catastrophizing), psychological variables (depression, anxiety, and experiences with injustice), mindfulness, self-compassion, and spiritual well-being were collected at three intervals: pre-, mid-, and post-intervention. *Results*. Repeated measures ANOVAs revealed a significant main effect of time indicating improvements over the course of the yoga program on the (1) anxiety subscale of the Hospital Anxiety and Depression Scale, $F(2, 18) = 4.74$, $p < .05$, and $\eta_p^2 = .35$, (2) Self-Compassion Scale-Short Form, $F(2, 18) = 3.71$, $p < .05$, and $\eta_p^2 = .29$, and (3) Magnification subscale of the Pain Catastrophizing Scale, $F(2, 18) = 3.66$, $p < .05$, and $\eta_p^2 = .29$. *Discussion*. The results suggest that an 8-week Hatha Yoga program improves pain-related factors and psychological experiences in individuals admitted to a rehabilitation and complex continuing care hospital.

1. Introduction

Yoga is an ancient mind-body practice that is embedded in Vedic traditions dating back to 3000 BC [1] and which is being applied in developed countries as a broad remedy to attenuate health-related symptoms in clinical populations [2, 3] across institutional, community, commercial, and private settings. Yoga is traditionally understood as cultivating concentrative awareness and a unified experience of the self through physical postures (āsana), breathing exercises (prāṇāyāma), inner awareness (pratyāhāra), concentration (dhāraṇā), and meditation (dhyāna), with consequent improved health through a separation process from afflictive cognitive, emotional, behavioural, and autonomic patterns and a shift towards adaptive coping skills [4, 5].

Yoga is garnering attention for its ability to simultaneously address multiple body systems (e.g., circulatory, neuroendocrine, musculoskeletal, respiratory, viscerosomatic, and immunological) through a dynamic and bidirectional process consisting of both top-down and bottom-up constituents and to yield benefits in well-being and symptom reduction [3, 5]. Burgeoning interest in yoga as a therapeutic intervention for a variety of health conditions has resulted in an expansion of research over the past decade, with the volume of publications increasing by threefold with up to 312 randomized controlled studies noted in 2013 [6, 7]. There are a plethora of lineages and schools of yoga that are evaluated in yoga research trials, but the style of yoga (e.g., aṣṭāṅga, iyengar, and hatha) does not impact the odds of producing positive outcomes for different conditions [8]. Across many of

these studies, yoga is extolled for its many benefits. However, the literature is plagued by studies of poor methodological quality and there has been a call for improving the caliber of research in this area [9].

There is evidence that yoga is effective in the treatment of a variety of acute and chronic conditions [9] either as a standalone treatment or as an adjuvant therapy, including low back pain [10, 11], arthritis [12], rheumatic disease and fibromyalgia [13, 14], diabetes [15, 16], cancer and related fatigue [17–21], stroke and related disability [22, 23], sleep disorders [24], renal disease [25, 26], hypertension [27, 28], asthma [29, 30], chronic obstructive pulmonary disease (COPD) [31], psychiatric conditions [32], obesity [33], and neurological conditions [34, 35]. Although there is an abundance of research evaluating the impact of yoga on disease-specific symptoms or quality of life for many chronic conditions, to date there has not been one trial evaluating the effects of a yoga intervention on individuals who are receiving care or rehabilitation for complex chronic disease and disability (CCDD).

CCDD is a term that identifies individuals who have been diagnosed with multimorbidities that affect psychological, social, physical, and vocational functioning and require ongoing health care resource utilization [36–38]. Individuals with complex health conditions have been identified as unique in terms of their specific health care needs and health-related experiences [36]. Although the disease combinations reported in multimorbidity are diverse, the most common diagnoses are diabetes, stroke, hypertension, cancer, arthritis, asthma, fractures, the presence of an artificial knee or hip, fatigue, multiple sclerosis, demyelinating diseases of the central nervous system, gonarthrosis, ataxia, COPD, dependence on renal dialysis, malignant neoplasm of breast/prostate, depressive episodes, and pure hypercholesterolemia [39, 40]. Consistent across studies of this population is the severity of the impact of having multiple conditions [41]. Patients with CCDD have an average of five health conditions (comorbidities) [40] and frequently reported pain, weakness, illness-related symptoms, functional challenges (mobility, activities of daily living, equipment devices, etc.), symptoms of anxiety and depression, and disruptions in independence, recreational activities, occupation, social roles, and self-identity.

Multimorbidity has been associated with low socioeconomic status, female gender, and older age in both longitudinal and cross-sectional studies, with prevalence and incidence rates in older age reported at 55% and 12–33%, respectively, and prevalence rates in young-middle age at 11.3–15.4% [42–45]. Multimorbidity is a complex and heterogeneous disease state, with many of the most prevalent conditions being of global concern, and is increasingly becoming the norm rather than the exception, resulting in high health care resource use [45, 46]. In Canada, 42% of total direct medical care expenses are allotted to the treatment of chronic diseases [47], with up to $52,661 per patient spent on average for the last year of life, in part due to inpatient and long-term care costs [48]. Despite the clear priority of the medical community to address the needs of individuals with chronic disease, the orientation of the health care system as an acute-care focused model means that care for individuals with chronic disease is often ineffective, leaving those with many chronic conditions underserviced [49].

A structural shift towards care that is not disease/injury focused but emphasizes addressing many needs at once has been recommended [50, 51]. Understanding the relationships between physical, psychological, and social factors of health in multimorbidity has been identified as necessary for creating effective treatment [38, 52]. A remodeling of chronic disease services has been proposed to create interventions that harmoniously integrate patient-centered and systemic factors and that also target risk factors, such as depression or functional ability, with the end goal of improving patient self-efficacy, functional health status, health-related behaviours, and psychological well-being [49, 53]. Despite an increase in research over the past two decades on multimorbidity, there is still limited research on effective interventions to adequately service this population [53, 54], which highlights a need for programs that are designed to address the needs of individuals who are managing multiple intersecting health impacts of a chronic nature.

Given the evidence supporting the use of yoga for many of the common primary and secondary diagnoses of patients with CCDD (e.g., musculoskeletal conditions, multiple sclerosis, hypertension, arthritis, renal disease, depression, diabetes, COPD, cholesterol levels, and breast and prostate cancer), it is possible that yoga may be able to address many of the multiple health needs these individuals report as being important [40]. Other frequently reported symptoms (e.g., pain, fatigue, emotional upset, nausea, and difficulty breathing) and facets of living that are disrupted (e.g., mobility, activities of living, and social well-being) have also been shown to improve with yoga practice [2, 19, 21, 55, 56]. Moreover, yoga provides a lasting behavioural skill set that increases confidence and self-efficacy and shows maintenance of functional and coping gains in chronic pain patients at follow-up [57]. It can be used in the treatment of chronic conditions for both low- and high-income populations, is associated with treatment adherence in sedentary adults, and holds promise as a cost-effective treatment for chronic conditions [58–61]. Complementary and alternative therapies such as yoga have been recommended for integration into clinical health psychology settings in order to more broadly address well-being, spirituality, multiple health problems, dissatisfaction with orthodox medicine, and disease prevention [62].

Although there is evidence that yoga provides mental and physical health benefits for many of the disease states and psychosocial impacts that are prevalent in individuals with multimorbidity, there have been no studies evaluating its use for this population. Medical rehabilitation and complex continuing care support tend to focus on addressing physical ailments and neglect integrating mental health support. Yoga is an example of a strategy that addresses both; thus it may impart benefits in multiple areas of health, rendering it particularly useful for this population. Hospital and tertiary care settings typically implement evidence-based practice, so there is a need for information regarding the benefits and safety of yoga when used in the treatment of individuals with CCDD or multimorbidity.

Table 1: Demographics of the sample ($N = 10$).

Demographic	N (%)/M (sd)
Age (years)	63.1 (16.6)
Height (cm)	163.6 (15.4)
Weight (kg)	70.7 (17.1)
Race/ethnicity	
African Canadian	2 (20%)
European (Italian/Croatian)	2 (20%)
Caucasian	6 (60%)
Socioeconomic class	
High	1 (10%)
Middle-high	1 (10%)
Middle	1 (10%)
Middle-low	2 (20%)
Low	5 (50%)
Level of education ($n = 9$)	
Grade school	2 (22.2%)
High school	2 (22.2%)
University/college	5 (55.6%)
Postgraduate school	0 (0%)

This study evaluated the impact of a specialized yoga program on pain, psychological, functional, and spiritual constructs in individuals receiving complex continuing care or medical rehabilitation. Given the complex presentation of impacts for this population, multiple measures were used to fully explore the possible effects of yoga across various aspects of experience. The study used a pilot cohort study design to test the following hypotheses: (1) scores on measures of pain, pain catastrophizing, stress, anxiety, depression, and experiences of injustice will decrease from pre- to post-intervention and (2) scores on mindfulness, self-compassion, and spiritual well-being will increase from pre- to post-intervention.

2. Materials and Methods

2.1. Participants. In order to be included in the study, participants had to be inpatients at Sinai Health System (Bridgepoint Hospital (BH) Site), be able to understand and speak English, and be cognitively able to understand instructions. Exclusion criteria included a regular yoga practice in the six months prior to the commencement of the study, an expected discharge date before the completion of the yoga program, or moderate cognitive impairment as indicated by a cognitive screen done by BH care team. Participants either were wheelchair users or were comfortable doing yoga from a seated position.

Demographic information and clinical characteristics of the sample are summarized in Table 1. Participants had all been admitted to BH in 2014 and were receiving either complex continuing care (CCC; $n = 9$) or medical rehabilitation (MR; $n = 1$). The one patient that was admitted for MR was informally transferred to CCC partway through the hospital stay for more intensive care. Examination of hospital records across a range of assessment dates indicated that participants had different levels of independence for tasks of daily living and mobility, such as transferring from a bed to a wheelchair. Information recorded within the hospital system is different for the complex continuing care and medical rehabilitation streams.

Both males ($n = 4$) and females ($n = 6$) participated in the yoga program. Height and weight were taken from hospital records for participants receiving CCC and if multiple weight assessments were provided, the weight assessment time closest to the start date of the yoga program was used. Weight and height were taken from self-report data for the participant receiving MR; secondary conditions were not reported for this patient. Participants had been diagnosed with at least one medical condition (see Table 2) and on average 7.6 ± 2.8 conditions. Although most conditions were accompanied by a formal disease diagnosis, some documented conditions were not necessarily accompanied by diagnoses (e.g., weight issues, allergies, pain, and instability). Participant use of various pain treatments (pharmacological, natural health products, physical treatments, psychological treatments, and medical interventions) are displayed in Table 3. The study researchers worked with hospital staff to obtain medical clearance notes for all participants, indicating that it was safe for participants to participate in an eight-week yoga program. Participants did not receive financial compensation for participating in the study.

2.2. Procedure. The research protocol was reviewed and approved by the Human Participants Review Committee at York University and by the Joint Bridgepoint Health, West Park Healthcare Centre, Toronto Central Community Care Access Centre (CCAC), and Toronto Grace Health Centre Research Ethics Board.

2.3. Research Design. This prospective, pilot study consisted of two parts: a Codesign Phase and a Research Intervention Phase. The Codesign Phase involved consultation with BH staff (Therapeutic Recreation staff, research scientists, the Chair of Complex Chronic Disease Research, the Director of Professional Practice, and a liaison to the research ethics board) to discuss the best approach to the yoga program development, delivery, and evaluation so that it would contribute to meeting the complex needs of the patients. As depicted in Figure 1, the Research Intervention Phase consisted of several components: an information session, yoga classes, follow-up meetings, and administration of self-report questionnaires. Questionnaires concerning pain and related variables, psychological factors, and mindfulness were administered at three time (T) points: pre- (T1), mid- (T2), and postintervention (T3). There were no subsequent data collection points in the time following the yoga intervention. The information session was held seven days before the yoga program began. The yoga program ran for eight weeks (one class/week) and the follow-up meetings took place after the final class and in the following few days. The information session and yoga classes were held in one of two auditoriums at the hospital.

Table 2: Primary and secondary conditions by participant ($N = 10$).

Participant	Primary diagnoses	Secondary diagnoses
1	Multiple sclerosis	Instability (report of having fallen).
2	End stage renal disease	Diabetes, hypertension, ischemic disease (unspecified), gastrointestinal issues, renal failure, moderate pain (less than daily), general instability (report of having fallen).
3	Klippel-Feil syndrome	Asthma, emphysema, moderate pain (daily), general instability (report of having fallen).
4	Superficial injury	Hypotension, cerebrodisease, arthritis, Parkinson's disease, asthma, moderate pain (both daily and less than daily), general instability (report of having fallen).
5	Cervical spondylosis	Osteoporosis, hemiplegia, anxiety, allergies, anemia, gastrointestinal issues, pneumonia, moderate pain (daily), general and acute instability (report of having fallen), skin issues (pressure ulcers, rash).
6	Intracranial hemorrhage (NOS, nontraumatic)	Hypertension, cardiovascular disease, aphasia, cerebrodisease, hemiplegia, allergies, pneumonia, urinary tract infection, weight issue, edema, moderate pain (daily), general and acute instability.
7	Hyperkalemia	Diabetes, arthritis, pneumonia, moderate pain (daily), report of having falling.
8	Neuromuscular bladder dysfunction (NOS)	Hypothyroidism, sclerosis (type not indicated), depression, mild pain (daily), general instability, skin issues (pressure ulcers, rash, desensitized skin).
9	Syncope and collapse	Hypertension, osteoporosis, depression, emphysema, gastrointestinal issues, moderate pain (less than daily), report of having fallen, anxiety.
10	Neuromyelitis optica/Devic's disease	Hemiplegia, sclerosis, depression, gastrointestinal, urinary tract infection, moderate pain (daily), general instability, skin issues (rash).

Table 3: Pain medications and pain treatments previously or currently used ($N = 7^*$).

Pain medications and treatments	N (%)	Participant number
Pharmacological medications (e.g., opioid-based medications, acetaminophen, and antidepressants)	7 (100%)	1, 3, 4, 5, 7, 8, 10
Natural health products (e.g., supplements and vitamins)	5 (71.43%)	1, 3, 4, 5, 8
Physical treatments (e.g., massage, acupuncture, physiotherapy, and exercise)	5 (71.43%)	1, 3, 4, 5,8
Psychological treatments (e.g., meditation, psychotherapy, distraction, and relaxation)	3 (42.86%)	3, 4, 8

Note. *Three participants did not record the use of pain medications or treatments.

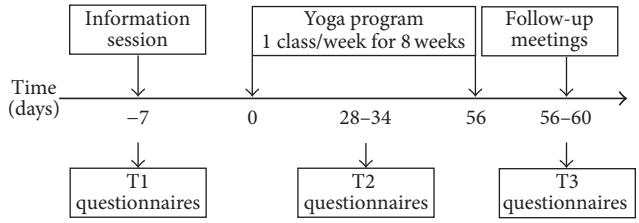

Figure 1: Time sequence of the study intervention. The information session was held seven days before the yoga program began. The yoga program was held once weekly for 8 weeks. Questionnaires measuring pain, pain-related variables, psychological factors, and mindfulness were evaluated at three time points: T1, T2, and T3.

2.4. Information Session and Data Collection. Interested individuals were informed about the yoga study by hospital staff (Therapeutic Recreation team members and support staff) and were screened for eligibility. Eligible participants attended the information session (T1) where they were given information about the investigators, the content of the yoga program, expectations for attendance and commitment, possible initial increases in pain due to exertion, and the homework component. Interested individuals had the opportunity to ask questions or voice concerns and those who decided to participate completed the consent process. After written informed consent was obtained, participants were provided with a canvas tote folder, which included an MP3 player with the homework audio files (see yoga program description), a copy of the consent form for their records, and a handwritten instruction guide to using the MP3 player with accompanying illustrations. Participants filled out a form with questions regarding demographic information, health history and current health status, and the questionnaire package. At T2, participants had the option of remaining after the yoga class to fill out questionnaires or taking the questionnaires back to their hospital room to fill out prior to the following class. At T3, participants filled out the questionnaire package after the final class.

2.5. The Yoga Program. The specialized yoga program consisted of an integrated approach to Hatha Yoga: postures (āsana), breath awareness exercises (prāṇāyāma), concentrative, meditative, and relaxation practices (dhāraṇā, dhyāna),

Table 4: Yoga philosophy concepts by class.

Class number	Concept	Explanation
1	Witness consciousness and ahimsā (nonviolence); Sūtra 2.35.	Practicing "being with" challenging experiences without pushing them away or clinging to personal narratives. Practicing in a way that is safe and supportive.
2	Satya (truthfulness); Sūtra 2.36.	Honestly examining one's experience to better understand one's "starting point" and using yoga practice as a springboard for positive change.
3	Breath awareness to balance the nervous system and calm the mind; Sūtra 1.34.	Pain management through relaxation, training the attention to see tension patterns in the body, and using imagery and visualization.
4	Sthira sukham āsanam; Sūtra 2.46.	Finding a balance between steadiness/stability/effort with ease/joy/relaxation.
5	Ekā gra (one pointed concentration); Sūtra 1.32.	Training attention and concentration by returning to a point of focus repeatedly.
6	Contemplation on the heart; Sūtra 1.36.	The heart as a resource, refuge, and source of inner luminosity.
7	Contemplation of kośas (sheaths/layers).	Five sheaths of the self: physical (annamaya), breath (prāṇāmaya), mind (manomaya), wisdom (vijñānamaya), and joy (ānandamaya). Practicing experiencing parts of the self without identifying with them.
8	Śavasana and the kośas.	Consolidation of all concepts. Cultivation of awareness of the layers of the self and a deeper part that can rest back and witness.

and yoga philosophy (jñāna) [63–65]. One of the most ancient scriptures of Hatha Yoga outlines yoga as a purificatory practice that balances the activities and processes of the physical body, the mind, and the overall energy level, in order to cultivate health, self-awareness, and inner development [65]. Hatha Yoga was selected as an appropriate form of yoga for individuals with chronic conditions and mobility restrictions as it is gentle and can be easily modified. The yoga philosophy component (see Table 4) was based on relevant contemplative and reflective practices from Patañjali Yoga Sūtras that focused on self-study, personal development, observances, yamas (ethical discipline), and attitudes of acceptance, among others [4, 64, 66]. Concepts found in classical scripture, such as the kośas theory of self, are being integrated in protocols for yoga interventions for chronic illness with a mind-body component [67]. The classes were one-third āsana, one-third relaxation training, and one-third yoga philosophy. The class format, structure, and content were designed in accordance with the yoga literature. A BH Recreation Therapy Assistant was present at each session. All participants practiced from a seated position, using either a wheelchair or a table chair to allow for uniform practice of the āsanas across participants.

Participants were provided with two recordings and were instructed to practice using the MP3 player twice a week. The first recording was a guided body scan awareness practice (~30 minutes) and the second recording was an āsana practice (~15 minutes). The participants were not given the second recording until they were familiar with the yoga āsanas and the teacher decided that they were safe to practice them on their own.

2.6. Measures

2.6.1. Brief Pain Inventory-Short Form (BPI-SF) [68]. The BPI-SF is a 9-item self-report questionnaire that measures various aspects of pain and pain interference with daily activities. The Brief Pain Questionnaire [69] and the Brief Pain Inventory [70, 71] were originally developed to evaluate cancer-related pain and have since been validated for other types of pain [72, 73]. In the BPI-SF, individuals are queried on pain history, are asked to visually depict pain locations on a human body diagram, and are asked to indicate best, worst, average, and current pain levels according to 11-point Likert scales, ranging from 0 (*no pain*) to 10 (*pain as bad as you can imagine*). Participants are also queried about pain medications and treatments and the perceived effectiveness of those medications. Finally, individuals respond to items regarding how pain interferes with seven domains of functioning: general activity, mood, walking ability, normal work, relations with other people, sleep, and enjoyment of life, according to 11-point scales ranging from 0 (*does not interfere*) to 10 (*completely interferes*).

The BPI has strong internal consistency (Cronbach's α = .85 and .88 for the intensity and interference scales, resp.), adequate construct validity (scores on the interference scale correlate with other pain disability measures) and is sensitive to treatment [70]. The BPI-interference items have been used in studies evaluating pain in individuals with SCI [74, 75] and have been recommended for use in this population, though item 9c, which refers to "Walking Ability," should be changed to "Ability to Get Around" [76]. It has excellent internal consistency ($\alpha > .90$) and is positively associated with pain intensity ($r > .60$) [77].

2.6.2. Pain Catastrophizing Scale (PCS) [78]. The PCS is a 13-item self-report questionnaire that measures catastrophic thinking in relation to experienced or anticipated pain. Participants are asked to read each item and indicate the extent to which they experience certain thoughts and feelings when experiencing pain by selecting a number from 0 (*not at all*) to 4 (*all the time*). Scores range from 0 to 52, with higher scores reflecting higher levels of pain catastrophizing. The PCS yields a total score and three subscale scores assessing rumination (focus on pain sensations), magnification (exaggerating the threat value of pain sensations), and helplessness (perceiving oneself as unable to cope with pain symptoms). The PCS has high internal consistency (coefficient α: total PCS = .87, rumination = .87, magnification = .66, and helplessness = .78) [78].

2.6.3. Perceived Stress Scale (PSS) [79]. The PSS is a 10-item self-report questionnaire that measures symptoms of stress over the past month, in relation to life events and relationships. Participants indicate how much they are experiencing their life as unpredictable and uncontrollable and how much they have felt overloaded. Each item is rated on a 5-point scale, ranging from 0 (*never*) to 4 (*very often*), with a highest possible score of 40, such that higher scores are indicative of higher levels of stress. It correlates well with other measures of stress, such as life events, and depression and anxiety scales and has satisfactory internal reliability (α = .78–.82) and test-retest reliability (r = .55–.85) [79, 80].

2.6.4. Hospital Anxiety and Depression Scale (HADS) [81]. The HADS is a 14-item self-report questionnaire that measures symptoms of anxiety (7 items) and depression (7 items). For each item, participants are asked to select one from among four possible choices (scored from 0 to 3) that best describes how they have been feeling over the past week. The HADS yields an anxiety (HADS-A) and a depression (HADS-D) subscale score, each with a maximum total score of 21, where higher scores indicate higher levels of anxiety and depression. Scores of 8–10 are considered cut-off points that are clinically meaningful for symptoms of anxiety and depression [81]. Internal consistency is high for both the HADS-A (α = .83) and HADS-D (α = .82) subscales [82]. Concurrent validity of the HADS is very good, as measured by correlation coefficients of between .62 and .73 for the HADS-D with various well-validated depression scales and correlation coefficients of between .49 and .81 for the HADS-A with various well-validated anxiety measures [82].

2.6.5. Injustice Experiences Questionnaire (IEQ) [83]. The IEQ is a 12-item questionnaire that evaluates feelings and thoughts of perceived injustice and severity of loss in relation to injury or pain. This scale is designed to evaluate cognitive appraisals that contribute to pain-related occupational disability. Individuals answer each item using a 5-point scale, ranging from 0 (*never*) to 4 (*all the time*). This scale has a total score and two subscales, blame/unfairness and severity/irreparability of loss. The total scale has good internal consistency (α = .92) and all items correlated above .05 with the total score [83]. This scale has been correlated with pain severity, pain catastrophizing, fear of movement, perceived disability, and depression (r = .54–.75, $p < .01$), indicating good construct validity. Cross-sectional regression analysis has shown good discriminant validity in that IEQ contributes to the variance of the predication of pain severity (β = .44, $p < .05$) [83]. Test-retest variability of the IEQ is good and scores across time are stable (r = .90, $p < .01$); authors note that the test-retest scores were more stable than scores on measures of pain and related constructs (e.g., PCS, Pain Disability Index, and McGill Pain Questionnaire) [83].

2.6.6. Five-Facet Mindfulness Questionnaire-Short Form (FFMQ-SF) [84]. The FFMQ-SF is a 24-item version of the original 39-item FFMQ and has been validated in individuals with depression, anxiety, and fibromyalgia [84]. It is a self-report questionnaire that measures levels of mindfulness according to five facets, which have acceptable model fit with the five-factor structure of the FFMQ. Those facets are observing, describing, acting with awareness, nonjudging of inner experience, and nonreactivity to inner experience. Participants respond to each item by selecting the number that is "most generally true" of his/her experience, on a scale of 1 (*never or rarely true*) to 5 (*very often or always true*). Total scores range from 0 to 120 and higher scores indicate greater levels of mindfulness. The FFMQ is based on a factor analytic study of five independently developed mindfulness questionnaires, with good internal consistency and construct validity [85, 86]. Total facet scores of the FFMQ-SF are highly correlated with the original version, r = .89, .89, .92, .96, and .95, for observing, describing, acting with awareness, nonjudging, and nonreactivity, respectively [84]. The correlation alphas are all above the defined criterion of .7 and all intercorrelations between facets and with other constructs are very virtually the same as the FFMQ. All the facets of the FFMQ-SF are sensitive to change and had moderate-large effect sizes [84].

2.6.7. Self-Compassion Scale-Short Form (SCS-SF) [87]. The SCS-SF is a self-report 12-item version of the original 26-item questionnaire [88] that measures levels of self-compassion. Self-compassion, as measured by this scale, is defined as the ability to hold one's feelings of suffering with a sense of warmth, security, or concern [87]. This short form has been demonstrated to have a unidimensional construct of self-compassion and also a multidimensional construct consisting of 6 subscales including self-kindness, self-judgement, common humanity, isolation, mindfulness, and overidentified; however, it is not recommended to use subscales for the short form version. The questionnaire queries respondents to indicate "how I typically act towards myself in difficult times," according to a scale of 1 (*almost never*) to 5 (*almost always*). This scale has been shown to have adequate internal consistency (Cronbach's $\alpha \geq .86$ for three different samples) and good correlation with the full version ($r \geq .97$ for three samples). The total score for the short form is calculated by dividing the total score by 12 (for each item) to produce a mean score (personal communication with Kristen Neff, April 19, 2016).

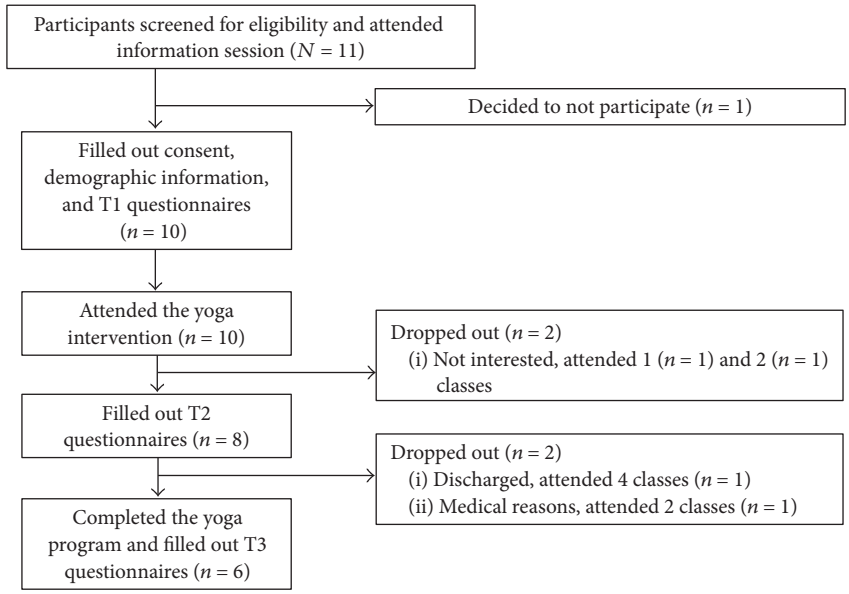

Figure 2: Participant flow through the study.

2.6.8. Functional Assessment of Chronic Illness Therapy-Spiritual Well-Being (FACIT-SpWB) [89]. The FACIT-SpWB is a 12-item self-report questionnaire that evaluates experiences of spirituality in individuals with chronic illnesses. The original scale has a total score and two subscales: meaning/peace and faith, although confirmatory factor analysis has validated the three-factor model in which meaning and peace are unique subscales [90]. Questions query themes of harmony and peacefulness and a sense of strength and comfort in one's beliefs. Participants answer each item using 5-point Likert scale, from 0 (*not at all*) to 4 (*very much*). This scale has good internal consistency for the overall index and for the two subscales (α = .81–.88). This scale also shows good validity; both the total scale and each subscales were positively correlated with measures of quality of life in cancer patients (Functional Assessment of Cancer Therapy-General) and negatively with measure of mood (Profile of Mood States) [89].

2.7. Data Analysis. Statistical Analysis was performed using SPSS Version 23 and SAS Version 94. Exploratory analysis was conducted to evaluate missing data and assumptions of normality. Raw data were evaluated for skew and kurtosis. All self-report measures were assessed for normality using the Shapiro-Wilk test. The self-report data were analyzed using repeated measures ANOVAs (T1, T2, and T3) and Bonferroni post hoc analysis in the presence of a significant main effect of time. Sphericity was evaluated using Mauchly's Test of Sphericity and, in the case of violations, Huynh-Feldt adjustments were used. Simple mediation analysis was conducted using a bootstrapping approach (2,000 resamples), as recommended for small sample sizes which may have violations of normality [91], to evaluate the mediating effect of total SCS scores at T2 on the relationship between HADS-A scores at T1 and T3.

3. Results

3.1. Preparation of Data. Data were analyzed by a protocol compliance (PC; $n = 6$) and intention-to-treat approach (ITT; $N = 10$). Although one of the participants had missed yoga classes 3 and 4 due to medical reasons, data were collected for this participant at T2 as they had not formally withdrawn from the study by that time. Therefore, for ITT analysis, data were carried forward from T1 for two participants and from T2 for two participants. One participant did not fill out the HADS questionnaire at T1, so T2 scores for this participant were used as a baseline score.

Data were explored for assumptions of normality. Values of kurtosis and skewness for all total scale scores at each time point were converted to z-scores for both PC and ITT data. At T1, all were within normal limits (<|1.96| at $p < .05$) except BPI-3 (significant skew). For PC data, all were within normal limits (<|1.96| at $p < .05$) except BPI-3 at T3 (significant kurtosis and skew) and BPI-5 at T3 (significant skew). For ITT data, all were within normal limits (<|1.96| at $p < .05$) except BPI-3 at T3 (and significant skew) and SCS-SF at T3 (significant skew). Similarly, the Shapiro-Wilk test revealed that all total scale scores were normal at $p < .05$, with the exception of violations of normality for BPI-3, $W(10) = .81$, $p < .05$, and BPI-6 at T1, $W(10) = .84$, $p < .05$, BPI-3-PC at T2, $W(8) = .80$, $p < .05$, BPI-3-PC at T3, $W(5) = .55$, $p < .05$, BPI-3-ITT at T3, $W(10) = .81$, $p < .05$, BPI-4-PC at T3, $W(5) = .75$, $p < .05$, BPI-4-ITT at T3, $W(10) = .84$, $p < .05$, BPI-5-ITT at T3, $W(10) = .81$, $p < .05$, and SCS-SF-total-ITT at T3, $W(10) = .74$, $p < .05$. Table 5 shows the means and sds for each measure across the three time points, as well as significant p values and effect sizes.

3.2. Demographic and Clinical Variables. Figure 2 shows the flow of participants through the study, which ran from October 28 to December 16, 2014. Eleven participants were

Table 5: Mean (sd) values for pain, psychological, and mindfulness variables across time, using Intent-to-treat sample ($N = 10$).

Measure	Preintervention (T1)	Midintervention (T2)	Postintervention (T3)	Significance (p value)
BPI-SF-3	6.90 (3.14)	6.80 (2.66)	6.90 (2.81)	ns
BPI-SF-4	4.50 (3.57)	3.60 (3.20)	2.70 (2.54)	ns
BPI-SF-5	5.20 (3.49)	4.50 (2.95)	5.00 (2.91)	ns
BPI-SF-6	6.80 (3.33)	5.30 (3.71)	4.60 (3.47)	ns
BPI-9-SF-total	29.10 (21.27)	23.70 (16.40)	25.50 (17.82)	ns
PCS-total	25.30 (15.62)	21.30 (14.77)	19.30 (12.19)	.099
PCS-helplessness	11.40 (8.58)	9.20 (8.20)	8.70 (6.45)	ns
PCS-magnification	4.50 (3.72)	2.70 (3.74)	2.40 (2.59)	.047[b]
PCS-rumination	9.40 (5.06)	9.60 (4.70)	8.20 (4.98)	ns
PSS	20.20 (7.83)	19.00 (8.27)	15.70 (8.17)	ns
IEQ-total	23.50 (7.11)	20.10 (9.55)	21.10 (11.49)	ns
IEQ-blame/unfairness	10.20 (4.13)	8.10 (4.46)	8.60 (6.10)	ns
IEQ-severity/irreparability	13.30 (4.35)	12.00 (5.91)	12.50 (6.00)	ns
HADS-A	9.00 (5.64)	7.70 (5.19)	6.50 (4.38)	.022
HADS-D	6.70 (4.99)	5.70 (3.83)	5.80 (4.05)	ns
FFMQ-SF-total	84.40 (7.66)	86.60 (10.05)	87.40 (12.40)	ns
FFMQ-SF-observing	15.70 (2.16)	16.80 (2.20)	16.80 (2.15)	ns
FFMQ-SF-describing	19.50 (2.64)	19.10 (3.87)	19.10 (4.09)	ns
FFMQ-SF-acting with awareness	18.10 (1.79)	19.60 (3.06)	18.60 (4.20)	ns
FFMQ-SF-nonjudging	16.90 (4.18)	16.70 (4.37)	17.10 (5.02)	ns
FFMQ-SF-nonreactivity	14.20 (2.20)	14.40 (3.10)	15.80 (4.87)	ns
SCS-SF	3.28 (0.77)	3.57 (0.63)	3.44 (0.58)	.047[a]
FACIT-SpWB-total	33.80 (8.13)	35.00 (9.01)	36.00 (7.45)	ns
FACIT-SpWB-faith	11.80 (4.57)	11.00 (5.29)	12.00 (5.29)	ns
FACIT-SpWB-meaning	12.70 (2.45)	13.50 (2.84)	12.70 (2.16)	ns
FACIT-SpWB-peace	9.30 (3.62)	10.50 (2.55)	11.30 (2.50)	ns

Note. Greenhouse-Geisser adjusted F-tests for significant main effects of time were conducted for SCS-SF.
Note. BPI-SF: Brief Pain Inventory-Short Form, PCS: Pain Catastrophizing Scale, PSS: Perceived Stress Scale-10 Items, IEQ: Injustice Experiences Questionnaire, HADS-A: Hospital Anxiety and Depression Scale-Anxiety, HADS-D: Hospital Anxiety and Depression Scale-Depression, FFMQ-SF: Five-Facet Mindfulness Questionnaire-Short Form, SCS-SF: Self-Compassion Scale-Short Form, FACIT-SpWB: Functional Assessment of Chronic Illness Therapy-Spiritual Wellbeing.
Note. [a]$p < 0.1$ for T1 versus T2; [b]$p < 0.1$ for T1 versus T3.

recruited by hospital staff and attended the information session, 10 of whom provided consent, filled out T1 questionnaires, and participated in at least one class of the yoga program. One participant decided not to participate after learning more about the questionnaire component of the research study. Data for eight and six participants were obtained at T2 and T3, respectively.

3.3. Yoga Program Attendance. Of the 10 participants who started the yoga program, six (60%) completed it. Three participants attended 1-2 classes and withdrew for personal or medical reasons, while one participant attended 4 classes, after which she withdrew as she was discharged early from the hospital. The mean ± sd number of yoga classes attended for all participants who entered the program ($N = 10$) was 3.72 ± 2.54 (out of 8 classes) and the mean ± sd number of yoga classes attended for all participants who completed the program ($n = 6$) was 6.83 ± 0.75 (out of 8). The mean ± sd number of participants who did some homework each week (listened to a recording 1–4 times) was 4.0 ± 1.83.

3.4. Treatment Results

3.4.1. Pain and Related Variables, Psychological Factors, and Mindfulness. Repeated measures ANOVAs did not reveal significant changes in any variable across time for the PC analyses. All analyses are reported according to the ITT principle as outlined above. Repeated measures ANOVAs revealed a significant main effect of time for HADS-A, $F(2, 18) = 4.74$, $p < .05$, and $\eta_p^2 = .35$, for SCS-SF-total (Greenhouse-Geisser adjusted F-test), $F(2, 18) = 3.71$, $p < .05$, and $\eta_p^2 = .29$, and for PCS-magnification, $F(2, 18) = 3.66$, $p < .05$, and $\eta_p^2 = .29$. Bonferroni comparisons revealed a trend for improvement from T1 to T2 for SCS-SF-total, $p < .07$, and for PCS-magnification from T1 to T3, $p = .08$. A repeated measures ANOVA also revealed a trend of improvement for main effects of time for PCS-total, $F(2, 18) = 2.63$, $p = .099$, and $\eta_p^2 = .23$. Individual score trajectories for scales with significant changes or trends for improvement are shown in Figure 3.

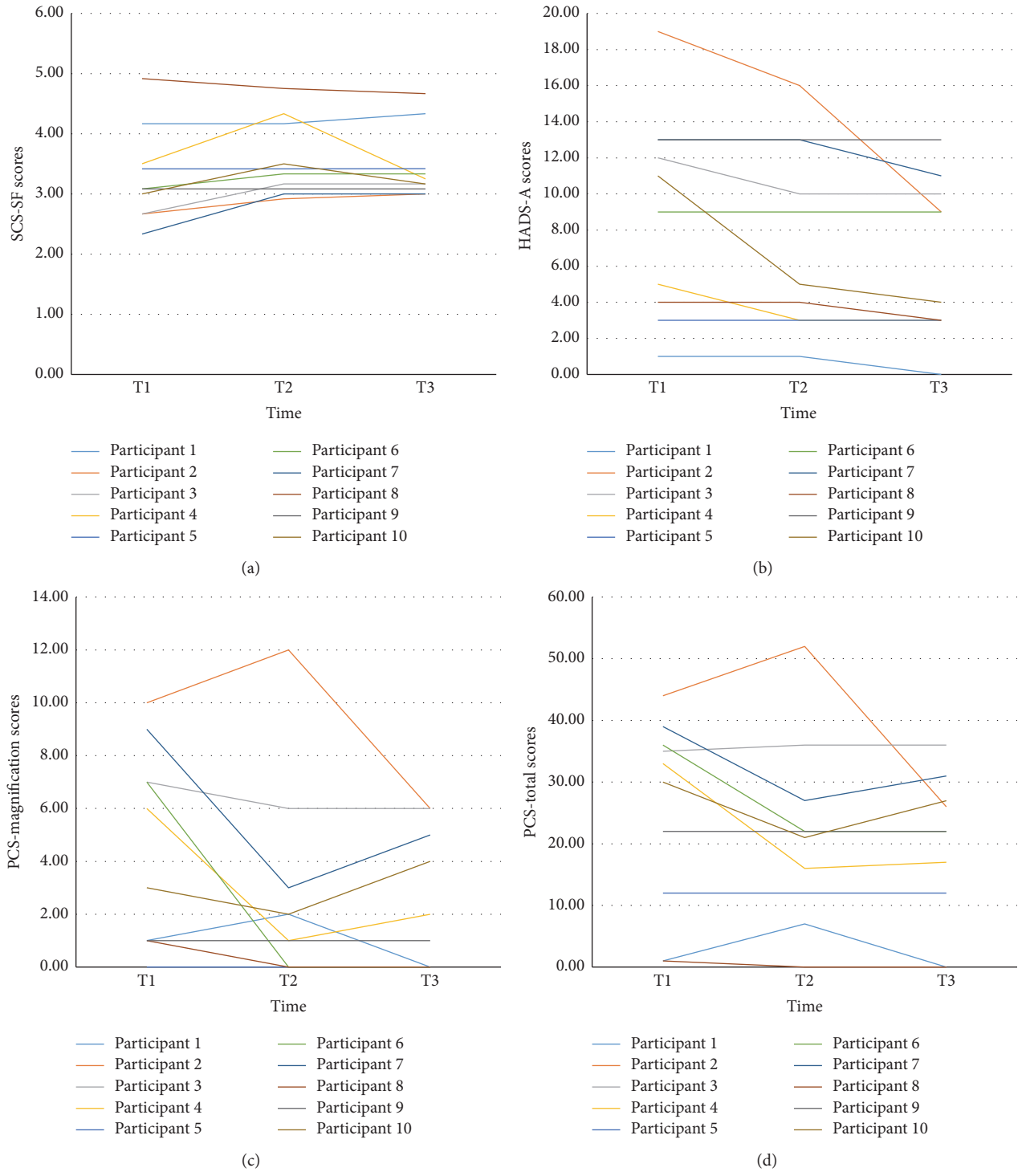

Figure 3: (a) Individual participant Self-Compassion Scale-SF (SCS-SF) scores by time. (b) Individual participant Hospital Anxiety and Depression Scale-Anxiety (HADS-A) scores by time. (c) Individual participant Pain Catastrophizing Scale (PCS)-magnification subscale scores by time. (d) Individual participant Pain Catastrophizing Scale (PCS)-total scores by time.

In terms of clinically meaningful cut-off points, 6 participants had scores above 8 on the HADS-A subscale at T1 and 4 participants had scores at or above 8 on the HADS-D subscale at T1. Out of the six true completers at the end of the study, there were 2 participants with scores above 8 on the HADS-A subscale and 1 participant with a score above 8 for the HADS-D subscale. Using the ITT scores for all participants, there were 5 participants with scores above 8 on the HADS-A subscale and 2 participants with a score above 8 for the HADS-D subscale. Visual inspection of the ITT

data revealed that each participant's score for HADS-A and HADS-D remained the same or decreased with the exception of 1 participant, whose score increased 2 points from T1 to T3 on HADS-D.

3.4.2. Mediation Analysis. Nonparametric bootstrapping analysis showed that the total effect of HADS-A scores at baseline on HADS-A scores at the end of the intervention was significantly reduced when SCS-SF scores at midintervention (the mediator) were added to the model (mean = 0.35, SEM = 0.33; $CI_{.95}$ = 0.05, 1.41). As such, the true indirect effect is estimated to lie between .05 and 1.41 with 95% confidence; as zero is not within the CI interval, it can be concluded that the indirect effect is significantly different than zero, $p < .05$, and that mid-treatment SCS-SF scores mediated the relationship between baseline and end-of-treatment HADS-A scores.

4. Discussion

This pilot study is the first reported trial to evaluate the effects of a yoga intervention on pain and related variables, psychological constructs, spirituality, and mindfulness in a sample of inpatients receiving complex continuing care/rehabilitation for multimorbidities. The results demonstrate post-intervention improvements in anxiety symptoms, the magnification aspect of pain catastrophizing, and self-compassion. As well, self-compassion was found to mediate improvements in anxiety from pre- to postintervention. These results suggest that a Hatha Yoga program specifically tailored to the needs of a hospitalized population experiencing multimorbidities may provide some psychological benefits.

The finding that anxiety scores were significantly lower after the eight-week program is consistent with RCTs that demonstrated improvements in anxiety and health outcomes in individuals with chronic diseases (diabetes or chronic low back pain) who participated in a yoga intervention when compared to walking or exercise/counselling control groups [92, 93]. A recent cross-sectional assessment of a large sample of individuals with a range of chronic illnesses found that self-reported duration of practice (practice session length and number of months practicing) predicted anxiety and the authors concluded that increased doses of yoga practice may help individuals respond to illness with lower levels of anxiety [94]. As well, systematic reviews document improvements in anxiety for several health populations that have participated in a yoga intervention, such as cancer, stroke, and irritable bowel syndrome [19, 31, 95]. In addition, low-income or noninsured individuals who participated in an integrated program involving mindfulness, self-compassion, and yoga, according to a single-group, repeated measures design, were found to have lower levels of anxiety and depression after intervention [96]. It is apparent that yoga provides psychological symptom improvement in both health populations and those who are impacted by low health care resources. This combination of experiences (health concerns, anxiety symptoms, financial strain, and a lack of resources) parallels the presentation of individuals with CCDD and indicates that yoga may reduce anxiety in the context of multiple health-related impacts.

Although pain catastrophizing has been less well studied in yoga trials, two studies (one pilot, one RCT) found that levels of pain catastrophizing were reduced from pre- to post-yoga interventions in samples of women with fibromyalgia [97, 98]. The present results are consistent with these studies in that we found the magnification aspect of pain catastrophizing (e.g., "I wonder whether something serious might happen") decreased from pre- to post-intervention. Pain catastrophizing is a strong predictor of pain severity, pain-related interference, disability, depression, and altered social support networks [99] and is associated with physical function deterioration in individuals with joint pain and comorbidity [100], highlighting it as a useful target for interventions that intend to increase functional ability in individuals with multimorbidity or CCDD. Other pain-related psychosocial factors, such as pain disability and pain acceptance, have been shown to improve with yoga practice [101]. Taken together, these findings provide some evidence that yoga may help to reduce the threat value attributed to pain stimuli or alter pain-related experiences in individuals with medical conditions in which pain is a predominant feature. As well, the potentially debilitating impact of pain-related disability or chronic health stress on financial and social independence for individuals with CCDD may amplify magnification cognitions, pointing to the utility of targeting this construct in yoga interventions.

The benefits of yoga extend beyond decreasing negative cognitive-affective experiences and can also serve to generate or augment a nurturing, positive, and discriminative approach to engaging with inner experiences. Self-compassion is a Buddhist concept that is increasingly being considered as an important mental health construct in Western Psychology and entails three main components: self-kindness, common humanity, and mindfulness [102]. The present findings that self-compassion increased significantly from pre- to post-intervention parallel the results from a yoga research trial in individuals living with an implantable cardioverter defibrillator [103]. The results of that study showed that participants who were randomized to a once weekly, eight-week yoga intervention reported increased self-compassion at the end of the trial compared to a usual care group [103]. For individuals with severe health impacts who typically use avoidance or distancing as coping strategies, a yoga practice may enable them to contact suffering and pain without judgmental or comparative thoughts [102]. Yoga philosophy didactics, which explain that inadequacies, failings, and suffering are considered part of the human condition (shared humanity), may normalize challenging experiences and enable individuals with CCDD to extend forgiveness towards their own short-comings and pain, rather than orienting from the stigma and marginalization that can accompany disability.

4.1. Mechanisms of Action. The finding that self-compassion mediated decreases in anxiety provides some support for self-compassion as a protective agent in distressing psychological experience and in helping to understand how yoga may be

exerting its mechanism of action. This construct has been identified in the yoga literature as one of seven possible mediators of yoga and stress; other mediators include psychological (positive self-affect and mindfulness) and biological (activity in the posterior hypothalamus and inflammatory and endocrine responses: C-reactive protein, Interleukin-6, and cortisol) pathways for therapeutic effects [104]. This is the first study to date that demonstrated the mediating role of self-compassion on psychological changes in a population experiencing medical concerns who participate in a yoga program. There is one previous trial that has demonstrated self-compassion and mindfulness as mediators of quality of life and stress in healthy young adults who participated in a four-month residential yoga intensive [105]. By contrast, self-compassion and mindful attention were not found to mediate changes in emotional stability in high school students who participated in a 16-week yoga program, when compared to students who participated in physical education as usual [106].

This construct may be more amenable to facilitating secondary mental health benefits in individuals experiencing illness-related duress and may impact how individuals cope with chronic and debilitating illnesses. It has been shown to change emotional responses, such as shame, and increase positive coping behaviours in individuals living with HIV and it predicts positive attitudes in the elderly, potentially serving as a buffer against the inevitable challenges associated with age decline [107, 108]. In addition, it is positively associated with both intentions to engage with and practice of health-promoting behaviours (e.g., eating habits, stress management, exercise, and sleep) with indirect effects through adaptive emotions (e.g., health self-efficacy, and positive affect), in community samples of Canadian adults [109, 110]. As the risk of multimorbidity increases with age, augmenting adaptive emotional responses to illness and health-promoting behaviours may assist in the prevention of further health decline and the promotion of well-being.

Although mindfulness was not a mediator of positive psychological change in the present study, previous yoga trials have reported that mid-intervention levels of mindfulness mediated changes in pain catastrophizing from pre- to postyoga intervention in women with fibromyalgia [97]. It may be that these constructs work by exerting different mechanisms during a yoga practice or that one may be more potent as a mediator for different populations or types of mindfulness or yoga interventions. Self-compassion has been demonstrated to be a more robust predictor of symptom severity (e.g., anxious and depressive symptoms) and quality of life than mindfulness in a large community sample of individuals seeking self-help for anxious distress and predicts emotional well-being more consistently than mindfulness in a sample of youth participating in a 5-day meditation retreat [111, 112]. Further examination between psychological well-being, mindfulness, self-compassion, and disability for individuals with CCDD in the context of a yoga intervention is warranted.

4.2. Attending to the Signals of the Body: New Pathways. The role of interoception, which is a complex and multimodal bodily system involving a sense of body parts in space (proprioception) and the act of attending, appraising, and responding to afferent body signals [113], has been considered as one of yoga's underlying mechanisms of action through the process of interoceptive exposure and reconditioning [97]. It is proposed that mind-body interventions, such as yoga, may interrupt habitual ways of perceiving and interpreting body sensations within the context of higher-order cognitive processes, such as goals and intentions, by connecting an individual with the present moment and with their agency for personal change [113]. In addition, it has been proposed that higher level brain networks that are activated by yoga practice may serve to inhibit negative appraisals, rumination, and emotional reactivity while lower level neural networks may downregulate physiological responses to stress, such as inflammatory markers and vasopulminary restriction, through the activation of the parasympathetic nervous system [5]. This is relevant in interpreting the results that pain catastrophizing decreased from pre- to post-interventions, as this construct involves exaggerated or negative cognitive-emotional appraisal of painful stimuli as threatening, is accompanied by perceived helplessness (lack of power), and is associated with aberrant central nervous system processes, such as cytokine or hypothalamic-pituitary-adrenal responses to pain, and activation of neural regions involved in processing affective components of pain [99]. It is clear that pain catastrophizing is a construct involving both emotional and biological processes and it may be that yoga helps individuals to reinterpret physical body signals for what they are, rather than as dangerous threats, through two elements of practice, practicing witness consciousness and then actively creating positive change in the body, which is then reinforced with practice through operant conditioning.

Self-compassion mirrors these two elements of traditional yoga practice, in that it involves a truthful recognition of one's inner state and selecting responses or behaviours that will alleviate suffering. It may be that, through yoga, individuals discover safety in opening to distressing experiences, circumventing, or offering a protective buffer against engrained ruminative or punitive "self-talk," and thereby create new ways of relating to self and prioritizing actions that are consistent with well-being and values. Higher levels of self-compassion have been associated with lower levels of catastrophizing, avoidance, and rumination in chronic pain patients who were presented with vignettes involving a violation of social contract and have been found to predict affect, pain disability, and pain catastrophizing in obese patients with chronic pain [114, 115]. The relationships between self-compassion, anxiety, and disability have been explored in individuals with Generalized Anxiety Disorder; these individuals display lower levels of self-compassion and mindfulness than healthy stressed controls and mindfulness was a better predictor of disability than actual anxiety symptoms, drawing potential protective effects of mindfulness on disability in individuals with chronic worry and physiological symptoms [116]. The relationship between self-compassion and anxiety should be further elucidated and it may be useful

to examine the relationships between the subscales of the SCS to better understand which components of self-compassion are most helpful in mediating changes in anxiety in clinical populations.

4.3. Limitations. There are limitations to the present study. The primary weakness is the absence of a control group, which is a shortcoming that is widespread in the yoga research literature, and makes it impossible to attribute the improvements observed to the yoga practice itself. As well, the small sample size limits power and introduces the possibility of type II error. Logistical limitations included participant difficulty in using the MP3 players and, as a result, reducing homework engagement and completion, which may have reduced overall efficacy of the eight-week yoga intervention. The difficulties that these patients experienced when using the technology are consistent with a previous report indicating that this population has challenges in paying attention and in using assistive technology [117]. Although the research team carefully selected devices with few buttons and minimal steps required to turn on and navigate the devices and also provided large print diagram instructions to accompany the devices, the population still experienced difficulty, which illustrates that they may be better serviced by yoga interventions that do not involve assistive technology for homework components.

4.4. Future Research. The researchers hope that these findings will be considered in the design and implementation of future research projects for individuals who are experiencing CCDD and associated pain, limited mobility, loss of functional ability, severe health impacts, and psychological sequelae. Future research trials should use a randomized, controlled trial study design with appropriate control conditions (e.g., wait-list, exercise, walking, or education) and a longitudinal design with follow-up intervals to determine lasting effects of a yoga practice [118]. Targeting self-compassion in the content and philosophy portions of the yoga interventions may enable researchers to further explore its mediating role of this construct on other psychological or physical experiences prevalent in this population. Trials that seek to further illuminate processes that underlie therapeutic gains may wish to use measures of self-regulation, self-compassion, stress, and positive affect alongside neuroendocrine-inflammatory markers of physiological status [104]. Evaluation of how these variables interact with pain-related constructs associated with the fear-avoidance model of chronic pain (e.g., chronic pain acceptance, pain-related disability, fear of pain, pain anxiety, and pain self-efficacy) may be warranted to better understand the converging impacts that result in distress and disability and with the end purpose to improve health and well-being.

5. Conclusions

The results of the present pilot project suggest that an eight-week specialized yoga program may help to reduce anxiety and the magnification component of pain catastrophizing and to increase self-compassion in patients with multimorbidity. This study provides preliminary evidence for yoga as an auxiliary care service that may be amenable to institutions that are in the process of evolving from single-disease treatment frameworks and that are seeking to assimilate programs and services that can address multiple, intersecting health concerns for various ages. The use of a randomized, controlled trial with a larger sample size and a more intensive yoga intervention design (e.g., two or more classes a week for 10–12 weeks) is recommended to further explore the relationships among pain, psychological experience, and mindfulness or spiritual constructs in individuals who are severely impacted by disease and disability.

Competing Interests

The authors declare that they have no competing interests.

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Research Article

Yoga Therapy in Children with Cystic Fibrosis Decreases Immediate Anxiety and Joint Pain

Christopher McNamara,[1] Mahrya Johnson,[2] Lisa Read,[2] Heidi Vander Velden,[2] Megan Thygeson,[2] Meixia Liu,[2] Laura Gandrud,[2] and John McNamara[1,2,3]

[1]*Children's Respiratory and Critical Care Specialists, PA, Minneapolis, MN, USA*
[2]*Children's Hospitals and Clinics of Minnesota, Minneapolis, MN, USA*
[3]*Department of Pediatrics, University of Minnesota, Minneapolis, MN, USA*

Correspondence should be addressed to John McNamara; john.mcnamara@childrensmn.org

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This study was designed to determine whether yoga might alleviate symptoms of pain, sleep disturbance, anxiety, and depression in children with cystic fibrosis (CF). CF is the most common genetic, life-limiting chronic disease among Caucasian populations. It primarily affects the lungs but also many other secretory organs and consequently leads to significant morbidities. Research has shown that children with CF have significantly increased depression, anxiety, and pain compared to their healthy counterparts. Subjects participated in six one-on-one sessions over a 10-week period with a certified instructor who designed each yoga practice based on a preestablished list of 30 yoga asanas. Questionnaires evaluating pain, sleep disturbance, sustained anxiety, immediate anxiety, and depression were administered. Differences between premeasures and postmeasures were evaluated using a two-sided test. Twenty subjects were assessed (12 females/8 males), median age of 11 (7–20) years. Mean immediate anxiety scores decreased (before session to after session 29 to 23.6, respectively, $p < 0.001$). Joint pain improved (3.25 to 3.65, $p = 0.028$). CFQ-R emotion subscale improved from 79.2 to 85 ($p = 0.073$), and the respiratory subscale improved from 66.7 to 79.2 ($p = 0.076$). Other results were less notable. We conclude that yoga may reduce immediate anxiety and joint pain in patients with CF.

1. Introduction

Cystic fibrosis (CF) is the most common genetic, life-limiting, chronic, multiorgan disease among Caucasian populations affecting approximately 30,000 children in the United States and 70,000 worldwide [1, 2]. Although recent advances in diagnosis and treatment have led to increases in lifespan, CF remains one of the most difficult chronic conditions to manage [3, 4] and patients with CF suffer from declining health-related quality of life as the disease progresses [5, 6]. Studies have shown that children with CF experience symptoms of pain, sleep disturbance, anxiety, and depression [7–19].

There is evidence in healthy populations that poor sleep is associated with negative behavior and decreased school performance [20, 21]. Cavanaugh et al. measured sleep quality in fifty subjects with CF (age 6–19 years) using actigraphy. Forty-two participants (84%) experienced poor sleep which was associated with worsening attention and attitude functioning [19]. In addition, there may be an association between decline in pulmonary function and sleep disruption [22] ultimately impacting quality of life for individuals with CF [14].

Anxiety and depression are well-recognized correlates of chronic illness [23–26] and have become an increasing concern in the CF community [4, 10]. These factors may contribute to decreased quality of life as well as decreased adherence to treatments [3, 4, 10, 27]. A meta-analysis evaluating 31 studies and 18,245 subjects with a variety of chronic health diseases revealed subjects with depression were 1.76 times more likely to be nonadherent to their treatment regimens [26].

As other secondary health conditions are increasingly identified in patients with CF, it is important to identify

Table 1: Study schema: timing intervals of yoga sessions, questionnaire administration.

	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6–10*	Week +1	Week +2
Yoga session	X	X	X	X	X	X		
STAIC	Before After	Before After	Before After	Before After	Before After	Before After		X
CFQ-R	X							X
MSAS	X							X
HADS	X							X
CES-DC	X							X
APSA	X							X

*Participants were allowed 10 weeks to complete 6 therapeutic yoga sessions.
(i) Before: test administered immediately prior to yoga session.
(ii) After: test administered immediately after yoga session.
(iii) X indicates the week a test was conducted.

and treat these issues in order to improve quality of life and treatment adherence. Complementary therapy offers a variety of symptom management techniques and may be particularly beneficial for those patients who deal with a complex chronic disease treatment regimen. A study, conducted in subjects with CF, assessed the prevalence of complementary or alternative therapy and demonstrated that 75% of subjects used at least one method of complementary/alternative therapy and described it as being helpful [28].

Yoga has become an increasingly popular complementary therapy to improve and maintain health and well-being. A growing body of research suggests that yoga has significant psychophysiological benefits and clinical relevance as a complementary therapeutic practice [29]. People who participate in yoga may benefit from improved muscle strength, flexibility, blood circulation, oxygen uptake, and hormone function [30]. Research suggests benefits of yoga for various diseases including respiratory disorders, cancers, rheumatoid arthritis, autism spectrum disorder, depression, obesity, diabetes, end stage renal disease, hemophilia, and gastrointestinal disorders [31–55]. Furthermore, it has been shown to improve psychological outcomes in adults with chronic obstructive pulmonary disease [56]. These findings extend to pediatric populations [42–48]. Similarly, evidence supports the efficacy of yoga in adults and children with asthma, showing improvements in quality of life, and, in some cases, improvement in pulmonary function and biochemical profiles, although more high quality research is needed [57–61].

These results set the stage for this study and the goal to explore the possible benefits of yoga in decreasing/alleviating symptoms of pain, sleep disturbance, anxiety, and depression and improving quality of life in children with cystic fibrosis.

2. Materials and Methods

2.1. Subjects. Subjects were eligible if they were between the ages of 7 and 21 years; had a diagnosis of CF; had no medical contraindications at the time of participation such as advanced liver disease, organ transplant, or severe pulmonary exacerbation; had no participation in an investigational treatment study within 30 days of enrollment; and were not participating in any other yoga practice. Subjects were recruited over the phone or at a clinic visit from both Children's Hospitals and Clinics of Minnesota and University of Minnesota. Subjects were enrolled after obtaining informed consent. The Institutional Review Board of Children's Hospitals and Clinics of Minnesota, Minneapolis, Minnesota, approved this study.

2.2. Yoga Certified Instructors and Training. Four certified yoga instructors were selected based on experience with yoga, pediatrics, and chronic disease. Each instructor had a minimum of 200 hours of yoga teacher training from certified yoga alliance schools such as Core Power and Atmananda Yoga Studio. Instructors participated in a two-day training for this study that included CF disease information, consistent use of preselected asanas (postures), administration of questionnaires, session planning/logistics, patient interaction/communication, and the facility/environment.

2.3. Intervention. Each subject participated in six private (one-on-one) yoga sessions over a ten-week period. Table 1 describes the timing intervals of the yoga sessions. Parents were asked to remain in the waiting room during each session. Sessions were spaced at least seven days apart. The ten-week period was selected to allow for flexibility with family schedules. Sessions were one hour in length and included 40 minutes of yoga practice with 10 minutes before and after the intervention to complete questionnaires and discuss the session activities. The same location/room was used for all sessions to reduce possible environmental influences.

To establish standardization, a preestablished list of 30 asanas and associated modifications were selected specifically for this study by the investigators who have also had yoga instructor experience. Each subject's yoga practice was designed from the preestablished list according to their energy levels, attitudes, physical limitations, and competencies on the day of the session. To maximize the impact of

each session, instructors were allowed to adjust the patient's practice within the preestablished list as needed. Because yoga typically allows for individualization of this nature, it was viewed as a potentially effective intervention due to the diverse needs of the CF population. Subjects were encouraged but not required to continue the yoga practice at home between sessions.

2.4. Questionnaires. The questionnaires (*Cystic Fibrosis Questionnaire-Revised* (CFQ-R), *Memorial Symptom Assessment Scale* (MSAS), *Hospital Anxiety and Depression Scale* (HADS), *Center for Epidemiological Studies-Depression Scale for Children* (CES-DC), and the *Additional Pain Symptoms Assessment* (APSA)) were administered to assess subjects' symptoms of pain, sleep, anxiety, depression, and quality of life immediately before the first session and two weeks after the last session. The *Spielberger State-Trait Anxiety Inventory for Children* (STAIC) questionnaire was administered before and after each yoga session to assess immediate anxiety reduction. Table 1 describes the timing of questionnaire distribution.

The STAIC is designed to assess both state anxiety, which is how a person feels at the immediate time, and trait anxiety, which describes how likely a person is to react with anxiety to a threatening situation [62]. For this study, we focused on the measure for state anxiety to evaluate a potential change in immediate anxiety levels.

CFQ-R is a disease-specific health-related quality of life questionnaire designed to measure the physical, emotional, and social impact of CF on pediatric patients [63, 64]. The CFQ-R also assesses five subdomains specific to cystic fibrosis: (1) body image, (2) eating disturbances, (3) treatment burden, (4) respiratory symptoms, and (5) digestive symptoms. Three versions of the CFQ-R were used: CFQ-R for ages 6 to 11 years, CFQ-R for ages 12 and 13 years, and CFQ-R for ages 14 to adults [64].

The MSAS assesses multiple symptoms in patients with advanced illnesses. The original tool allows for assessment of 32 symptoms and three dimensions of frequency, severity, and distress. Subscales for analysis include physical distress, psychological distress, and a global distress index [65]. The tool was validated with cancer patients and has been adapted multiple times for use in research with a variety of populations with advanced medical illnesses [66]. A subscale for CF adults was validated for this tool in 2008 with a study that examined symptom prevalence and characteristics in 303 adult patients with CF [67]. Two versions were used for this study: MSAS for ages 7 to 12 and MSAS for ages 10 to 18 [68, 69].

The HADS is a validated 14-item instrument that screens for depression and anxiety in children 12 to 18 years of age who have chronic medical conditions. This validated questionnaire has been used extensively in several countries and is available in different languages [70]. The 14 items are divided into subscales for anxiety and depression, both of which were used for this study. CES-DC is a validated 20-item instrument that evaluates symptoms of depression for ages 12 to 18 [71–73]. This tool was selected in addition to the HADS because it evaluates symptoms of sleep as well as depression. The CES-DC includes three dimensions: behavior, cognition, and happiness.

The APSA is an unvalidated questionnaire developed at our institution in an effort to thoroughly assess pain symptoms that are not captured in other tools. The survey specifically documents abdominal, chest, limb, and joint pain experienced by subjects in the previous two weeks with the frequency of pain rated on a Likert scale of 1–4 (1 = always, 2 = often, 3 = sometimes, and 4 = never) as follows.

Additional Pain Symptoms Assessment. In the past two weeks did you have any of the following:

Abdominal Pain?

- □ Always
- □ Often
- □ Sometimes
- □ Never

Chest Pain?

- □ Always
- □ Often
- □ Sometimes
- □ Never

Limb Pain?

- □ Always
- □ Often
- □ Sometimes
- □ Never

Joint Pain?

- □ Always
- □ Often
- □ Sometimes
- □ Never

All questionnaires were given to subjects based on the age at enrollment. The MSAS, CES-DC, and HADS were completed by subjects over the validated age range, but not by subjects below the validated age range. Table 2 describes the validation age and purpose of each questionnaire.

2.5. Analytic Approach. Median and range (or mean and standard deviation) were used to describe the continuous variables such as mean STAIC score. The nonparametric Wilcoxon Paired Signed Ranks Test was used to compare before and after scores of anxiety, depression, pain, sleep disturbance levels, and quality of life measured by STAIC, CFQ-R, MSAS, HADS, and CES-DC. A Chi-square test was used to compare the subjects with sleep difficulty before and after yoga sessions. McNemar test was used to compare the binary variables between preintervention and postintervention. All tests employed an alpha level of .05 and were two-sided. We also used the Benjamini-Hochberg Technique (1995) to control the False Discovery Rate across all comparisons in Table 4 [74]. SPSS V15.0 was used to conduct the analyses (SPSS for Windows version 15.0, SPSS Inc., Chicago, IL).

Table 2: Questionnaires: age validation and purpose.

Tools	Validation	Purpose
STAIC	6–17 years of age	Anxiety
STAIC	18+ years of age	Anxiety
CFQ-R	6–14+ years of age	Quality of life
MSAS*	7–18 years of age	Pain and sleep disturbance
CES-DC*	12–18 years of age	Depression
HADS*	12–18 years of age	Anxiety and depression
APSA	Not validated	Pain

*The MSAS, CES-DC, and HADS were completed by subjects over the validated age range but not by subjects below the validated age range.

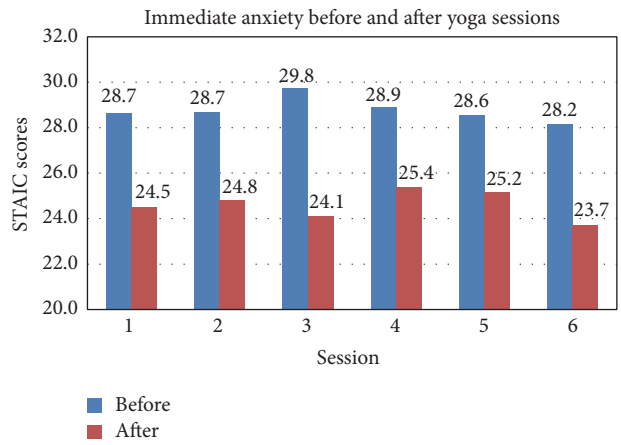

Figure 1: STAIC questionnaire: average mean scores for immediate anxiety reduction before and after yoga sessions: all subjects.

3. Results

A total of 21 subjects with mild CF lung disease were enrolled in the study. One subject withdrew and 20 subjects completed the study. Analysis included 8 males and 12 females with a mean age of 11 years (range 7 to 20) and mean FEV1%P (forced expiratory volume in 1 second) of 86%. Table 3 describes the study population demographics. Nineteen subjects completed six individual yoga sessions and one completed only five sessions due to a CF related respiratory illness. All sessions were completed within a rolling ten-week timeframe. Table 4 shows all the results with notable findings in bold. Only the STAIC remained significant after adjusting for the false positive rate.

Immediate anxiety improved from before each session (median 29, range 19–39) to after each session (median 23.4, range 20–30) on the STAIC ($p < 0.001$) (Figures 1 and 2). Scores for immediate anxiety also improved when comparing before the first session (median 28, range 19–39) to after the last session (median 26, range 20–31, $p = 0.024$). Sustained anxiety and depression did not show improvement on the CES-DC or HADS.

The CFQ-R showed no notable improvements in quality of life. The domains emotion from before (median 79.2, range 33.3–100) to after (median 85, range 33.3–95.8) yoga intervention ($p = 0.073$) and respiratory before (median 66.7, range 38.9–100) to after (median 79.2, range 38.9–100) yoga intervention ($p = 0.076$) trended towards significance. There were no notable findings for social impact, physical, eating disturbances, body image, social impact, treatment burden, and digestive symptoms.

Pain was evaluated by the MSAS and the APSA. The MSAS showed no notable improvement in self-reported pain. Forty-five percent ($n = 9$) of subjects experienced pain before intervention compared to 35% after ($n = 7$, $p = 0.625$). The APSA showed an improvement in joint pain from a mean score of 3.25 before intervention to 3.65 after intervention on a scale of 1 to 4 with 3 indicating sometimes having joint pain and 4 indicating never having joint pain ($p = 0.028$).

The MSAS showed no notable changes in sleep disturbance with 25% ($n = 5$) of subjects reporting difficulty sleeping before intervention compared to 15% after ($n = 3$, $p = 0.687$). The domain for sleep difficulty before (median 0, range 0–3) to after (median 0, range 0-1) yoga intervention trended towards significance ($p = 0.088$).

There was one adverse event of respiratory illness reported during the study, which was not considered related to the yoga therapy/intervention.

4. Discussion

Recent advances in the diagnosis and treatment of CF including universal newborn screening and preventive treatments for complications have led to dramatic improvements in lifespan. As life expectancy improves, researchers are evaluating secondary sequelae including pain, sleep disturbance, anxiety, depression, and decreased quality of life that cause psychological distress [10]. This burden is significant in this patient population and we aimed to assess if therapeutic yoga might help alleviate some of these effects.

A previous study in our center assessing symptoms among 39 subjects with CF, ages 7 to 18 years, found that 72% of subjects experienced depression, 16% expressed problems with sleep, 37% experienced moderate to severe long-term anxiety, and 29% complained of pain (abdomen, chest, limbs, and joints) [11]. A similar study evaluating pain in a group of 46 subjects with CF, ages 8 to 18 years, found that 50% of subjects experienced stomach pain, 37% chest pain, and 33% head pain [7].

After systematic review [75, 76] we found only one prior study performed by Ruddy et al. to evaluate yoga as a complementary therapeutic practice in children with cystic fibrosis [76]. The study presented here is the largest to date and the first with a primary aim is to evaluate therapeutic benefit; however, this is a pilot study and the results should be considered suggestive but not conclusive. The other study was a prospective pilot study conducted primarily to evaluate the safety of a standardized yoga program for patients with cystic fibrosis. The mean (SD) CFQ-R respiratory domain

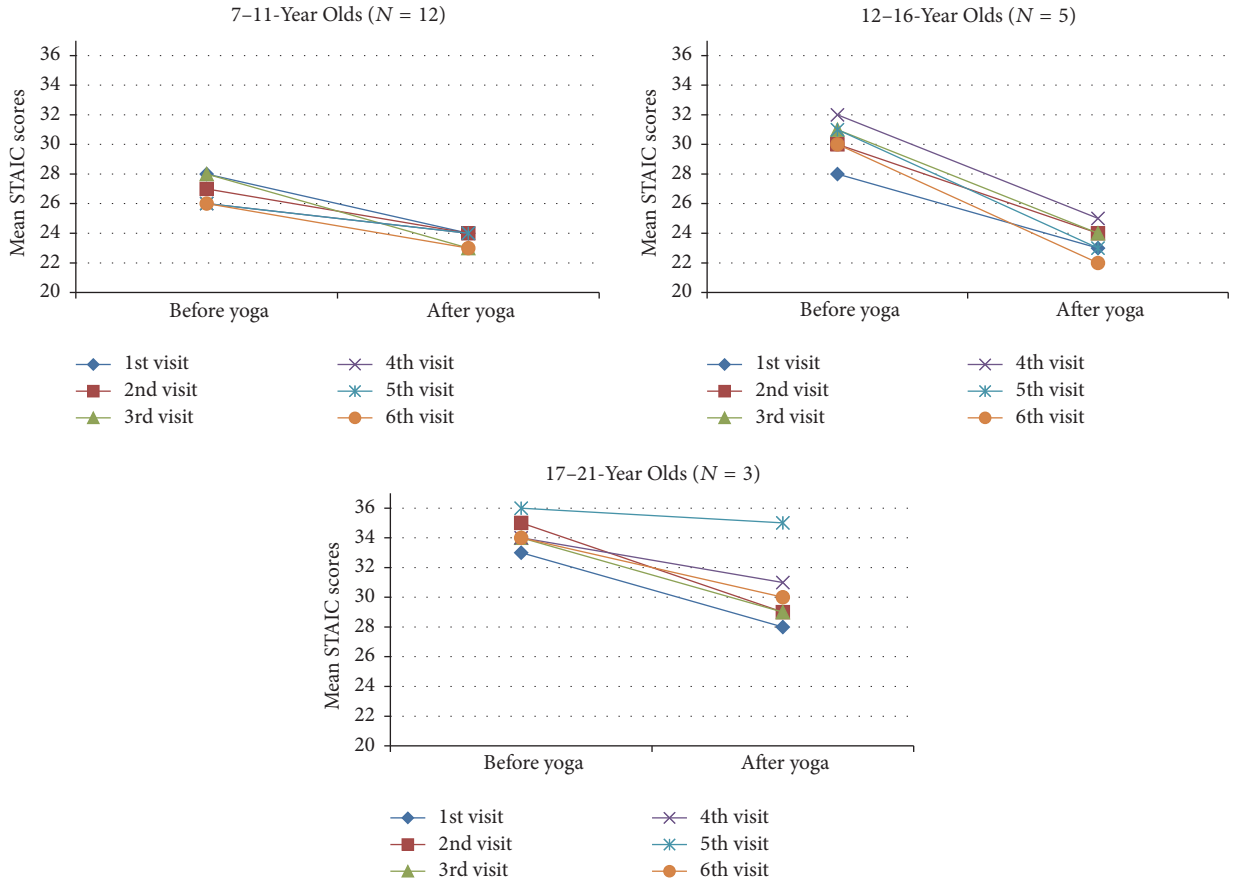

Figure 2: STAIC questionnaire: average mean scores for immediate anxiety reduction before and after yoga sessions: by age groups.

Table 3: Demographics Data.

Study ID	Gender	Ethnicity	Age	Baseline FEV1%P*	Lung disease Severity**
001	F	Caucasian	14.7	86%	Normal
002	F	Not answered	13.1	116%	Normal
003	F	Not answered	14.7	71%	Mild
005	M	Caucasian	12.1	96%	Normal
006	M	Caucasian	11.9	82%	Normal
007	F	African American	17.2	82%	Normal
008	F	Caucasian	9.7	57%	Moderate
009	M	Caucasian	9.0	83%	Normal
010	F	Hispanic	14.0	66%	Mild
011	M	Caucasian	11.9	95%	Normal
012	F	Caucasian	19.5	94%	Normal
013	F	Caucasian	8.7	116%	Normal
014	M	Caucasian	10.0	89%	Normal
015	M	Caucasian	7.6	102%	Normal
016	M	Caucasian	7.6	74%	Mild
017	F	Caucasian	19.4	74%	Mild
018	F	Caucasian	8.9	75%	Mild
019	F	Caucasian	7.1	52%	Moderate
020	F	Caucasian	7.3	111%	Normal
021	M	Caucasian	7.3	106%	Normal

*FEV1%P is the forced expiratory volume in 1 second.
**Lung disease severity measured by FEV1%P: normal is ≥80%, mild is 60%–79%, moderate is 40–59, and severe is ≤40%.

Table 4: Results of 6 Yoga sessions over a ten-week intervention in children with cystic fibrosis.

Measure	*N*	Before intervention	After intervention	*p* value
STAIC, median (range)	20	28 (19, 39)	26 (20, 31)	**0.024**[*]
CFQ-R, median (range)				
Emotion		79.2 (33.3, 100)	85 (33.3, 95.8)	**0.073**
Physical		83.3 (54.2, 100)	85.4 (45.8, 100)	0.924
Social impact		84.5 (47.6, 95.2)	76.2 (42.9, 95.2)	0.393
CF specific domain				
Body image		83.3 (22.2, 100)	88.9 (33.3, 100)	0.287
Respiratory symptoms		66.7 (38.9, 100)	79.2 (38.9, 100)	**0.076**
Digestive symptoms		66.7 (33.3, 100)	72.2 (33.3, 100)	0.748
Treatment burden		55.6 (22.2, 100)	66.7 (0, 100)	0.629
Eating disturbances	20	94.4 (22.2, 100)	88.9 (22.2, 100)	0.721
MSAS				
Pain, *n* (%)		9 (45)	7 (35)	0.625
Sleep difficulty, *n* (%)		5 (25)	3 (15)	0.687
Sleep difficulty, median (range)	20	0 (0, 3)	0 (0, 1)	**0.088**
HADS, median (range)				
Anxiety		8.5 (0, 15)	9 (1, 15)	0.497
Depression	10	6.5 (0, 12)	8 (0, 12)	0.491
CES-DC, median (range)	10	16.5 (0, 28)	16 (10, 42)	0.141
APSA				
Abdominal pain, median (range)		4 (1, 4)	3.5 (1, 4)	0.564
Chest pain, median (range)		4 (3, 4)	4 (2, 4)	0.480
Limb pain, median (range)		4 (2, 4)	4 (2, 4)	0.248
Joint pain, median (range)		4 (1, 4)	4 (2,4)	**0.033**[*]
Joint pain, mean (95% CI)	20	3.3 (2.8, 3.7)	3.7 (3.4, 3.9)	**0.028**[*]
		Before each session	*After each session*	
STAIC, median (range)	20	29.1 (19, 39)	23.4 (20, 30)	<**0.001**[**]

[*] Significantly different at $\alpha = 0.05$.
[**] Significantly different at $\alpha = 0.05$ adjusting for 18 comparisons (only STAIC remained significant after adjustment for multiple variables).
STAIC: immediate anxiety. Total score ranging from 0 to 60, lower score is better.
CFQ-R: scaled score between 0 and 100, higher is better.
MSAS: scaled score between 0–4 for each domain, lower is better.
HADS: scaled score between 0 and 21, lower is better.
CES-DC: scaled score between 0 and 60, lower is better.
APSA: scale of 1 to 4, higher is better.

score increased significantly from screening to end of study, 67.9 (11.40 to 82.1 (9.9)), ($p = 0.04$) in the 10 participants who completed the program. No other outcome measures reached significance and it was recommended that further testing with larger trials be conducted [76]. Twenty participants completed the yoga program offered at our site. As with Ruddy et al. [76], the subjects in our study tolerated the yoga therapy safely.

Our most notable finding was an improvement in immediate anxiety from before each yoga therapy session (median 29, range 19–39) to after (median 23.4, range 20–30) on the STAIC ($p < 0.001$). Prior to study participation immediate anxiety levels for the study population were within normal limits when compared to the general population for this age group. However, STAIC scores trended towards improvement from immediately before a single yoga session to immediately after a session as shown in Figure 1. Additionally, the first questionnaire completed at enrollment compared to the last questionnaire at the follow-up visit showed a significant decrease in immediate anxiety ($p = 0.024$). Increased anxiety levels may impair attention and disrupt cognitive information processing [77], so an intervention that is able to reduce immediate anxiety may provide real benefit. One subject expressed how, when feeling anxious at school, she practiced a breathing technique that she learned from her yoga instructor and found the method to be helpful. Unfortunately, we were not able to show any notable improvement in sustained anxiety or depression.

The APSA showed a notable improvement in reported joint pain from prior to initiating yoga therapy to after the conclusion of yoga sessions ($p = 0.028$). The MSAS, a tool that measures more generalized self-reported pain, decreased from 45% of subjects experiencing pain before treatment to 35% after but, with the admitted limitation of our small

sample size, was not notable ($p = 0.625$). Pain is significant in patients with CF [7, 11] and it is a symptom that people with CF of all ages experience with an increase in severity and duration with age, unrelated to disease severity [77, 78]. Yoga may be helpful for managing at least some of these pain symptoms. Beginning the practice and lifestyle of yoga early in life may provide larger benefits later in life.

The CFQ-R emotion subscale, which addressed feelings of worry, loneliness, sadness, and the desire to make future plans, did not show notable improvements ($p = 0.073$). The respiratory subscale also did not show notable improvements ($p = 0.076$) in our study. It is worth noting that the Ruddy et al. study did show a significant improvement in the CFQ-R respiratory subscale in their ten-participant cohort ($p = 0.04$) with a more intense session period (twice a week for 10 weeks), but they were also unable to show significant improvement in the emotion subscale ($p = 0.13$) The Ruddy et al. protocol was to practice yoga twice a week for 8 weeks and had a mean attendance of 14 sessions [76]. Larger controlled trials may be warranted to further investigate yoga and quality of life improvements in patients with CF, especially since yoga has been shown to increase quality of life scores in other chronic disease populations including breast cancer, rheumatoid arthritis, and children with hemophilia [40, 42, 51] as well as respiratory diseases such as asthma [79].

The study presented here did not show notable improvement in sleep difficulties with yoga therapy but did demonstrate a trend towards significance in sleep difficulty before (median 0, range 0–3) to after (median 0, range 0-1) yoga intervention ($p = 0.088$). The prevalence of sleep difficulties is well documented in the CF population [8, 11–19] with possible etiologies including nocturnal hypoxemia preventing REM sleep [12, 13] and nocturnal cough.

4.1. Limitations. Our study demonstrated two promising and notable outcomes of reduction in pain and immediate anxiety which suggest a trend towards improvement despite the low power of our 20-participant cohort. Demonstrating significance in this small, healthier CF cohort may have been a limitation since our population has excellent pulmonary outcomes overall. Thus, a lower pain prevalence and symptomatic burden within our population is expected. This study lacked a control group, which may have strengthened our findings. We did not assess the duration of the short-term anxiety relief experienced. While this study demonstrated an immediate improvement in anxiety, we do not know if this relief lasts minutes, hours, or days. To this end, questionnaires assessing general anxiety administered during the yoga therapy period would be of interest. We did not have a validated tool for patients with CF to assess localized pain such as limb and joint.

Our study was limited by the small number of yoga sessions: 6 sessions over 10 weeks for 19 participants and 5 sessions for 1 participant. It is possible that the intensity and duration of the yoga therapy in our study were too small, with too few yoga sessions spread too far apart over too short a time. Larger studies with an objective measurement of sleep quality, such as with sleep actigraphy, during an experimental yoga therapy trial may be beneficial.

5. Conclusions

This yoga session interventional pilot study for patients with CF demonstrated a notable decrease in immediate anxiety from prior to and just after yoga therapy sessions. This study also showed a notable decrease in reported joint pain from before the trial of yoga therapy began to after it was completed. Yoga as a complementary therapy may be a valuable option for patients with CF who are experiencing pain or anxiety related to their health, school, or social activities. Our results are consistent with the literature that yoga is safe and well tolerated in children and adolescents with mild to moderate lung disease. Our findings of notable improvements in a small pilot study with a relatively low dose of yoga therapy and other measures trending towards significance suggest that larger controlled trials conducted to determine the benefits of yoga for patients with CF would be valuable.

Competing Interests

No competing financial interests exist.

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Research Article

Yoga Helps Put the Pieces Back Together: A Qualitative Exploration of a Community-Based Yoga Program for Cancer Survivors

Michael J. Mackenzie,[1,2] Amanda J. Wurz,[3] Yayoi Yamauchi,[4] Lanie Ann Pires,[1] and S. Nicole Culos-Reed[5,6,7]

[1]*Department of Behavioral Health & Nutrition, University of Delaware, Newark, DE, USA*
[2]*Department of Human Development & Family Studies, University of Delaware, Newark, DE, USA*
[3]*School of Human Kinetics, Faculty of Health Sciences, University of Ottawa, Ottawa, ON, Canada*
[4]*Graduate School of Sport Sciences, Waseda University, Tokyo, Japan*
[5]*Faculty of Kinesiology, University of Calgary, Calgary, AB, Canada*
[6]*Department of Oncology, Cumming School of Medicine, University of Calgary, Calgary, AB, Canada*
[7]*Department of Psychosocial Resources, Tom Baker Cancer Centre, Alberta Health Services, Calgary, AB, Canada*

Correspondence should be addressed to Michael J. Mackenzie; mmackenz@udel.edu

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Objective. A qualitative research methods approach was used to explore the experiences of participants in an ongoing community-based yoga program developed for cancer survivors and their support persons. *Methods*. 25 participants took part in a series of semistructured focus groups following a seven-week yoga program and at three- and six-month follow-ups. Focus groups were transcribed verbatim and analyzed using a process of inductive thematic analysis. *Results*. The group was comprised of 20 cancer survivors, who were diagnosed on average 25.40 (20.85) months earlier, and five support persons. Participants had completed the yoga program an average of 3.35 (3.66) times previously and attended approximately 1.64 (0.70) of three possible focus groups. Four key themes were identified: (1) safety and shared understanding; (2) cancer-specific yoga instruction; (3) benefits of yoga participation; (4) mechanisms of yoga practice. *Conclusions*. Qualitative research provides unique and in-depth insight into the yoga experience. Specifically, cancer survivors and support persons participating in a community-based yoga program discussed their experiences of change over time and were acutely aware of the beneficial effects of yoga on their physical, psychological, and social well-being. Further, participants were able to articulate the mechanisms they perceived as underpinning the relationship between yoga and improved well-being as they developed their yoga practice.

1. Introduction

Approximately 1.9 million individuals are diagnosed with cancer each year in North America [1]. Medical advances have resulted in improved survival rates for most cancers [2]; however, survivorship is not without its challenges. Cancer is amongst the leading cause of morbidity and mortality in North America [3], negatively impacting psychosocial (e.g., mood and lack of perceived social support) and physical health (e.g., increased risk for comorbid conditions and secondary malignancies; [4]). Given the severity and duration of negative effects, many cancer survivors seek self-management strategies to regain control over their body, lessen the impact of cancer and its treatments on their psychosocial and physical health, and improve their overall quality of life [5]. Yoga has emerged as one such self-management strategy.

Contemporary yoga practice is a gentle activity that combines physical movement (i.e., *asana*), breathing techniques (i.e., *pranayama*), and meditation (i.e., *dhyana*; [6]).

In studies with cancer survivors, positive effects have been noted for a variety of outcomes, including mood, cancer-related distress, symptoms of fatigue, and overall quality of life [6–13], though there is some variance in the magnitude of improvements reported [14]. Notwithstanding these discrepancies, the cumulative evidence suggests yoga may be particularly beneficial to combat negative cancer-related effects, holding immense potential as a valuable addition to currently accepted supportive and complementary healthcare services.

Given the preliminary support for yoga in cancer survivorship, further research is required to better understand the experiences cancer survivors have after engaging in yoga programs. Qualitative research is one way researchers may be able to better understand the complex phenomena of yoga participation. Specifically, qualitative research offers distinct advantages by including the voices of participants and providing rich and detailed information that may not be obtained otherwise [15]. As such, a qualitative research approach may be an ideal way for researchers to better understand the complex phenomena of yoga practice for individuals diagnosed with cancer.

To date, few researchers have qualitatively explored cancer survivors' experiences after participating in yoga interventions and programs. van Uden-Kraan et al. [16] conducted a preliminary qualitative exploration with breast cancer survivors participating in weekly yoga classes for 16.8 months. The authors found breast cancer survivors' ongoing participation stemmed from an interest in fostering body awareness, developing relaxation skills, and increasing physical activity as a means to cope with cancer and its treatments as part of rehabilitation. With regard to the self-perceived effects of yoga, participants reported a sense of shared understanding with fellow breast cancer survivor participants and reported experiencing heightened physical fitness, mental strength, resilience, and enhanced coping. Similarly, Galantino et al. [17] explored the benefits of an eight-week yoga intervention for breast cancer survivors coping with aromatase inhibitor-associated arthralgias. The authors found participants experienced an increased sense of camaraderie and community within the program, self-reported pain and stress relief, increased fitness, and an ability to use the skills fostered in yoga practice in daily living (particularly the breathing techniques). Duncan [18] conducted a six-month community-based yoga intervention with a heterogeneous group of cancer survivors; quantitative and qualitative data were collected. Participants self-reported clinically significant reductions in symptoms and mood disturbance and improved quality of life and spiritual wellbeing. The qualitative exploration confirmed and extended these findings, indicating participants attributed improvements in physical well-being to yoga practice and experienced a greater sense of emotional well-being. Moreover, study participants were appreciative of the individualized instruction they received, which they felt bolstered their own self-efficacy (i.e., confidence; [18]). Research conducted by McCall et al. [19] in an outpatient setting found yoga practice reduced stress and other symptoms associated with cancer treatment. In addition, group yoga practice was found to promote prosocial behavior and encourage personal empowerment during cancer treatment and recovery. Taken together, these studies highlight some of the factors underpinning participation in yoga by cancer survivors.

Although these studies contribute to the field, much remains unknown about how participants experience change in yoga practice over time and how self-perceived benefits develop in the context of a community-based yoga program. Further, perspectives from support persons have yet to be explored. Including the voices of support persons' experiences in a yoga program are necessary as cancer's impact extends beyond the patient. Support persons also report impaired physical, psychological, emotional, and social functioning and well-being, resulting in increased levels of distress and reduced quality of life [20]. Thus, research is required to provide an in-depth understanding of both cancer survivors and their support persons' participation in a community-based yoga program. The present study sought to address this gap by exploring both cancer survivors and support persons experiences following a seven-week community-based yoga program. A qualitative research approach was used to explore participants' experience of change over time and better understand how self-perceived benefits are accrued via the phenomenological lens of the participants in the yoga program.

2. Methods

2.1. Participants. Ethical approval was obtained from a Research Ethics Board (REB) and all participants completed an REB-approved informed consent prior to study enrollment. Program participants were comprised of a heterogeneous group of cancer survivors enrolled in the ongoing "Yoga Thrive: Therapeutic Yoga for Cancer Survivors" program, as described previously [21]. The Yoga Thrive program is a research-based, therapeutic yoga program for cancer survivors and their support persons. This seven-week program is based on contemporary yoga practices modified for cancer survivors [21, 22]. Participants were eligible for study inclusion if they (1) were aged 18 years or older and (2) had received a cancer diagnosis at any time previously or (3) were a support person of a cancer survivor coattending the Yoga Thrive program. Previous participation in the Yoga Thrive program was not an exclusion criterion but was evaluated as part of the study. Participants were informed of the research study at the time of registration for the Yoga Thrive program, via either telephone or email. The study coordinator then contacted those who indicated interest in participating in the qualitative component of the research study.

2.2. Procedures. Once recruited into the qualitative portion of the study each participant engaged in up to three separate one-hour semistructured focus groups completed after the program (i.e., following the seven-week yoga program or at three- and six-month follow-ups). The use of several focus groups allowed participants to describe how their experience of yoga practice shifted over time. In total, ten focus groups were conducted over a period of six months (four at follow-up, four at three-month follow-up, and two at six-month follow-up). Focus groups were comprised of

both cancer survivors and their support persons who had participated in the Yoga Thrive program. The aim of the focus groups was to elicit conversations concerning participants' experiences in the yoga program in conjunction with their cancer experience (see Qualitative Research Questions). The focus group approach permitted discussion and allowed for data to enter the interview that was not directly sought, thus allowing participants to provide information they believed was important and relevant to them [23]. As a result, questions asked varied between each focus group. Main points were summarized by the researcher at the end of each focus group for the purpose of member-checking and credibility [18]. All focus groups were conducted in the community and audiotaped with consent.

Qualitative Research Questions

(1) Post-Seven-Week Yoga Program Focus Groups

(i) Tell me about your experience in the yoga program.

(ii) Why did you decide to participate in the yoga program?

(iii) What did you expect when you started to practice yoga?

(iv) What was it like for you when you started out?

(v) What has changed for you practicing yoga from the beginning of the program until now?

(vi) What motivated you to continue the program?

(vii) What do you think you have learned from this program?

(viii) What did you like best/least about this program?

(ix) What do you think are some of the benefits/deficits to practicing yoga?

(x) What effects, if any, have you noticed since joining the yoga program?

(xi) What role does yoga play in your cancer recovery?

(xii) When people don't practice yoga as often as they'd like, why not?

(xiii) What suggestions do you have for us to improve the program?

(xiv) What additional information would you like to add today?

(2) Three- and Six-Month Follow-Up Focus Groups

(i) Tell me about your yoga practice since completion of the program.

(ii) What has changed for you practicing yoga from completion of the program until now?

(iii) What effects, if any, have you noticed since completing the yoga program?

(iv) What has motivated you to continue practicing yoga?

(v) What do you think are some of the benefits/deficits to practicing yoga?

(vi) What role does yoga play in your cancer recovery?

(vii) When people don't practice yoga as often as they'd like, why not?

(viii) What additional information would you like to add today?

2.3. Qualitative Analysis. All focus groups were transcribed verbatim and analyzed using the NVivo 9 computer program (QSR International, 2010). The program allows for the organization of textual data into categories, themes, and subthemes and facilitates management of a large volume of textual data. All focus groups were conducted by a single researcher (MM) then coded independently by two research assistants (AW and YY) using a process of inductive thematic analysis [15]. Inductive thematic analysis is a process of coding that allows the data to drive the analysis (as opposed to deductive analysis which involves fitting the data into preexisting categories or themes). Both coders reviewed the transcripts several times to familiarize themselves with the textual data and then raw data quotes were identified, labeled, and organized into key themes. Common themes were then combined into higher order categories. These preliminary themes and categories were compared and contrasted between the research assistants to assure consistency of coding and to ensure all data were accounted for by core categories. Emerging themes were triangulated with the inclusion of several participant cases [24]. Codes identified by the two research assistants were then reviewed and verified as a team with the principle investigator and a second coder (MM and LP) over the course of several meetings. Next, the thematically categorized research findings were integrated with the subjectively reported experience of participants. Specifically, direct quotes were provided from participants to substantiate key themes and ensure transferability of categorical assertions made by the researchers, so that readers could experience participant perspectives in their own words [18].

3. Results

3.1. Participants. The group was comprised of 20 cancer survivors (M_{age} = 56.14; SD = 8.93) who were diagnosed on average 25.40 (20.85) months earlier and 5 support persons (M_{age} = 71.73; SD = 18.88). Participants were predominantly female (88%) and had completed treatment for breast cancer (n = 11), cervical cancer (n = 1), colorectal cancer (n = 2), lymphoma (n = 2), ovarian cancer (n = 2), and prostate cancer (n = 1). Treatment modalities included surgery (n = 16), chemotherapy (n = 13), and radiation (n = 11) and/or combinations thereof. Participants had completed the Yoga Thrive program an average of 3.35 (3.66) times previously and attended approximately 1.64 (0.70) of three possible focus groups.

3.2. Inductive Thematic Analysis. Qualitative analyses of the focus groups offered insight into participants' experiences with the yoga program. Four broad themes were identified: (1) safety and shared understanding; (2) cancer-specific yoga

instruction; (3) benefits of yoga participation; (4) mechanisms of yoga practice.

3.2.1. Theme 1: Safety and Shared Understanding. Participants indicated attending a yoga class comprised of other cancer survivors provided feelings of safety and shared understanding of the cancer experience: "It's a very safe environment. We all have that common thread (cancer). It kind of draws you together and helps you to open up." Shared understanding of cancer was a uniting force for participants providing feelings of comfort and support: "Whether you are the spouse or partner of someone who had cancer, or actually had cancer yourself, everybody is kind of healing. It starts to make you a survivor instead of a victim of it (cancer)." Despite being at different stages (i.e., on-treatment, off-treatment, and support person), participants still felt connected to one another: "You are all at different stages physically and different stages in recovery, but you have all been through it (cancer) or are going through it, so that means a lot." This sentiment was common: "Coming here with other cancer patients, I guess we're all in the same kind of… gone through similar experiences." This identification with other cancer survivors though oft-repeated was summarized when a participant reflected on her experience when a new cancer survivor joined a yoga class she was registered in: "When she walked across the room I thought, '*wow, that's all of us…*' That's why I think you feel comfortable here." Participants attributed this shared meaning through the cancer experience as a safe place in which they could work together to learn a new skill: yoga.

For several participants the safety and shared understanding within the cancer-specific yoga program precluded them from trying yoga elsewhere, "I thought, '*I will do yoga elsewhere.*' Well that was the biggest mistake… I could not keep up and I walked out of there almost in tears. I felt so horrible, thinking I was doing so well, then I go to a class and can't do it. It was a heart wrenching experience… I hate to say it, I am almost afraid to step outside that boundary (of Yoga Thrive) because I don't know what to expect." Another participant shared, "I did sign up for yoga in my community at the same time. I did the Yoga Thrive and I thought, '*I'm not doing the community one.*' It was just too scary. For me, I wasn't comfortable telling people that I had cancer. I don't want to go into another class and tell them, '*Well I have had cancer and I have these injuries.*' I didn't want that. I didn't feel that with (Yoga Thrive). It was like everybody is in the same boat." For another participant who had suspended her regular yoga practice during treatment, "Yoga was so restorative. It was just wonderful and such a good step to come back into yoga because I had done it previously. I took that whole year (cancer diagnosis and treatment) off, and got away from it (yoga) then I built up this fear of going back into regular mainstream yoga. When I saw that poster (Yoga Thrive) I took it off the wall so I would have it for the minute I was done (cancer treatment) and could get back into it because I loved it before and equally am finding it so beneficial now."

The discussions around the cancer-specific nature of the yoga program were complex. For many, despite acknowledging the benefits of a shared experience, it was the focus on yoga and not their cancer experience that was valued. "The cancer thing was too overpowering for me. I didn't want to be about that. So (yoga) is not about cancer. I have tried doing other cancer things and I am just not taken to it anymore… I have moved on." Several other participants commented on the importance of shifting the emphasis from shared cancer experience to yoga practice itself. "It's not focused on the cancer but the focus is on the well-being of the individual and that's very positive." Another participant shared, "I didn't really want to belong to a '*cancer club*' afterwards (post-treatment)… but the yoga appealed to me because it was physical, but then it was just such a safe, nice environment." Extending this notion, for a small group of participants, it was the focus on improving their own health and well-being, and not necessarily being around similar others that was important. As one participant stated, "I really wanted to find something that was just going to be for me – to help me feel better, to feel stronger. It had nothing to do with cancer. That's what I love about this yoga." Similarly, another participant said, "It really had more to do with helping me period, '*Help me – Me*' which really in my head had nothing to do with cancer at the time."

While participants appreciated the shared understanding and safety of practicing yoga within a cancer-specific program, many expressed fear around engaging in yoga beyond Yoga Thrive. The camaraderie they found within the cancer-specific yoga program was second for many to the focus on the practice of yoga itself within this environment.

3.2.2. Theme 2: Cancer-Specific Yoga Instruction. In addition to feelings of safety and shared understanding, many participants commented on the cancer-specific yoga training of the instructors and the corresponding individualized and progressive nature of the yoga instruction, "The strength of the program is the way of instruction. It's very compassionate, humane and encourages you to try different things and continually grow. It's sort of the opposite of '*no pain no gain*'… It's very respectful of your body." Participants suggested that given the nature of class instruction this further engendered a sense of safety and ability to work to one's fullest potential throughout each class.

> *One of the neat things during the class is that I have never felt intimidated by not being able to do something. I love the fact that there is always a suggestion (from the yoga teacher), "Well if you can't do that you can try this instead, and, you're still getting some benefit from it." You're not sitting there waiting for everybody to finish the pose, so you're always a part of it, you're participating in it.*

This theme was reiterated among several participants.

> *I am going to attend a class instructed by somebody who understands I may have limitations because of my physical experience - whether it be surgery, chemo, radiation or whatever else… I wanted to be in a class led by somebody who would… not just respect I have limitations, but also understand what they might be, and know what I should and shouldn't do.*

Participants appreciated the yoga instructors had received cancer-specific training, even if they did not recognize it consciously when they first registered for the program. "So yes, it's somebody who would understand and not just respect that I have limitations initially, but also understand what they might be. That would obviously have to be somebody who would understand that if you had a mastectomy if you had lymph nodes removed or if you didn't and therefore, what restrictions you may have physically and what you shouldn't be doing as well. Not just what may not be able to but what you shouldn't be doing. So now that - that was probably subconsciously." This specialized instruction was a key factor in putting participants at ease, largely informing their decision to participate in yoga. However, it should also be noted that for some this appreciation for cancer-specific yoga training stemmed from fear of injury and the role of the instructor in potentially mitigating perceived harm: "I did it (cancer-specific yoga program) because I was afraid of injuring myself. I thought if I went to any other yoga they wouldn't know (understand) what had happened. I felt this would cater more to people who had surgery or were going through other treatments. . . I wasn't afraid of going to this." Given the varied levels of practice and physical and psychosocial health that participants entered the program with, the adaptations the instructors offered were greatly appreciated. Whether specific to their cancer experience or not, participants suggested the challenge of yoga practice and trying the different yoga postures allowed them to, "find out where my body wasn't quite doing it the way I should be, and knowing where I needed to work on. . .There's a bit of challenge to think about each time and what could I work on to get a little better at." Another participant stated, "There was a pose variation where you could put your foot against your thigh or higher on your ankle. All I could manage was the ankle. I appreciated that adaptability to the range of abilities that were there."

Interestingly, for this study, participants had a wide range of experience with the Yoga Thrive program. For those who had taken the program before versus first time participants, experienced participants appreciated ongoing modifications the yoga instructors provided as they continued to practice. "There are different levels: some are new and some have been there a long time. She (the yoga teacher) is able to give us a little bit more, for those of us who have been there for a while. Just a bit more information about the pose, minor details that you wouldn't introduce at the beginning but now we are ready for. So now you can focus on it. You are learning and doing more that the last time you did the class. . . Even though we have done it so many times, I still find I learn something every time."

Participants appreciated the yoga instructors' cancer-specific training. They shared that this also provided a degree of safety and shared understanding, allowing instructors to offer appropriate modifications for participants based on their current needs and abilities. For more seasoned practitioners more detailed instruction allowed them to further grow over time as they improved and deepened their yoga practice. Although classes were comprised of individuals at varying levels on the cancer trajectory and a range of levels of yoga experience, the ability of the yoga instructor to adapt, modify, and safely guide the group was helpful across the cancer and yoga experience continuum.

3.2.3. Theme 3: Benefits of Yoga Participation. Although cancer and its treatments exert a tremendous toll on cancer survivors and support persons, in the program, yoga was described as both a respite and means of taking control back: "For me it was very restorative and helpful for me to start as soon as I did." Support persons agreed with this sentiment and also found yoga to be a reprieve in the ongoing support they provide.

> *What I think I got was you come with your own burden as a family member around the responsibility and what it looks like in the future and what's that going to mean. The benefit I didn't appreciate before. I was thinking I was helping just by signing us up. I think it relieves your own stress by normalizing some of that discussion around cancer if it came up. People who were living with it in different ways, seeing other people cope with it. I found it relieved my own stress around being the support system for someone who was living with cancer. That was an added benefit. I thought I was helping him (by co-attending the program), but it really does help as a partner in that sort of progression of living with cancer. I didn't anticipate that. That's why I enjoy it too, because it relieves some stress and takes some of that burden away to feel like I am the only option. . . it has provided in the same way for me as it has for him. I wasn't expecting that.*

This feeling of relief from the symptoms of cancer and its treatments was attributed in part to the control participants felt the yoga program gave them: "I like to feel I have some control over my life. That is one of the huge benefits I have got from the program. . ." Several participants echoed this sentiment.

> *You're never discouraged – it's something I have chosen to do: something I have control over. It is at a time in your life when you have very little control over anything else that could happen physically to you. So that to me was huge. I make the decision, "I am attending. I can do this." It was getting that control back of my body I guess really. . . I don't know how you can get that across to people?*

In addition, participants used the yoga program to confer psychosocial and physical benefits. Specifically, the most commonly reported benefits of yoga were an increased ability to relax, concentrate, and regulate emotions, manage symptoms of fatigue, pain, and sleep difficulties, and promote physical health. For example, participants commented on how yoga allowed them a space to relax and encouraged them to slow down. One participant commented: "This is more gentle and relaxing - it's just a different way of doing things. . .I think the yoga just kind of calms your whole body and mind." Another participant further suggested yoga, "helps me go into

my body or heart instead of my mind. It slows it all down." Yoga also honed participants' ability to concentrate: "To stop and focus," and regulate their emotions. The emotional benefits often occurred acutely, with participants noticing a significant shift before to after class: "I leave in a good mood every single time. I have never left yoga in a cranky mood ever." Yoga's utility to assist with symptom management was described by many participants. Other respondents described how yoga improved their physical health by improving their mobility and strength: "It really does help physically. . .I could feel my physical strength improve."

For many there was also a shift in focus from the physical to mental benefits of yoga. "I think I originally enrolled for the physical benefits. The mental benefits came later." One participant stated, "It took me, I would say, the majority of the time to just calm down and take in more of the therapeutic aspect and enjoy it. At the beginning I just kept thinking, '*OMG this isn't getting me anywhere*' and I couldn't focus. I just wanted to get more physical, thinking that's what I needed. . .At the end I thought, '*Wow that was good!*' I just calmed down and my whole perspective changed. I started enjoying the class." These benefits were often also experienced outside of class, "When I am worried or thinking or going off, I will stop and just try and breathe. I try to incorporate what I have learnt in the class." Others posited emotional benefits, "If I am feeling emotional or some stress in my life before I would just keep spinning and spinning and getting tighter and tighter. Now it's like I have learned a tool to help me relax and let go of a lot of stuff. It's tremendously emotionally helpful. The techniques, tools you learn in yoga are applicable to everyday life: everywhere you go, everything you do." Another participant suggested, "One thing it has done for me is help me separate myself from situations so that my emotions and moods don't get tangled up in something that doesn't have to do with me personally, it's just the situation I happen to be in. It helps me take one step back and look at it from an outside perspective. Put things in place where they need to be."

Although many spoke of the benefits of yoga practice, these changes were not immediate for many, "The first while doing down dog (a yoga posture) was killer but I just. . . did it and now I shock myself at my strength in some of that stuff. . . The chemo had tightened all the muscles in my body and so I think going to yoga has helped counteract that." Another shared, "I remember first starting out and I wasn't very good at anything, never mind getting on the floor, but when the instructor would say, '*You got it!*'. . . It was almost like, '*Wow, I was never able to do that and now I can do this!*' Those little moments make you feel really good because you've come a really long way in comparison to what you were doing. I'm still struggling, but it's like a goal to reach for. I may never be good at all of it, but it's one pose at a time." Another participant shared, "First of all I didn't really know what to expect. . . Then when you do the moves, you don't really have the feel of your body. . . When you start to know what to expect you have that mind-body thing. . . You start to be calm and can focus on the moves, you can go much farther. I don't know how to explain it. . . it is like a mind-body thing. You feel your body and you not only see the instructor and everybody else, but you actually start to focus on yourself. I didn't do that in the beginning."

Although the majority of participants commented on the benefits they received through yoga practice, some participants highlighted that fatigue, a common side effect, was a significant barrier that may have mitigated the full extent of the benefits they received from program participation. "As far as fatigue goes, I don't know if yoga has played a part in it. . . of the entire experience that's the one thing I struggle with. It's taking such a long time to come back. I can see a huge shift from where I was, but I still have that (fatigue). If I wasn't in yoga would it be any better? Hard to say." Another participant offered, "The yoga was good even when I did take it when I was tired. I did get some benefit even as I realized at the time that it was kind of a chore to go. . . Even though it was once a week some nights I thought, '*Well I signed up, this is supposed to be good for me. . .I'm just really tired. I'd rather just stay home.*' But anyways I went." Participants also clearly and candidly described how the benefits accrued varied based on where they were in their cancer treatment continuum (i.e., on- or off-treatment). Some participants indicated they did not receive the full benefit of yoga practice initially. "I had just finished chemotherapy and radiation when the yoga started. I thought it would be okay but. . . I think all of the treatments started to accumulate and I was really tired all the time. I didn't get as much benefit out of it as I should have I think. Whether mentally I was tired or physically I was tired, it was just not the right time for me, you know?" Despite the lack of change, the participant continued in the program, "A year later was much better and I really enjoyed it." This feedback suggests yoga may have had limited utility in combatting more pronounced treatment-related side effects during active treatment. That said these individuals continued their yoga practice.

Finally, participants were careful to fully ascribe their recovery to yoga practice, "I am very careful to say if it is the yoga or that I am getting rid of all the poison I had in me with the chemo. I know I'm going much farther with the yoga now because I'm at peace. I'm ready to do things when I'm finished with my (yoga) exercises." Another participant commented, "I am back to doing everything, back to where I was prior. It could be the yoga, it could be a bunch of other contributing factors, but I am still doing my yoga with the belief that it helps me. It is good for my continued recovery."

Participants described a host of physical, mental, and emotional benefits from yoga practice inclusive of symptom management. However, these benefits were not immediate and rather were a function of continued yoga practice. Fatigue and treatment-related barriers were often highlighted as challenges participants faced in their yoga practice and in many cases impeded the full range of benefits from being derived. In general participants did not view yoga as a panacea but saw it as an important component of their cancer recovery.

3.2.4. Theme 4: Mechanisms of Yoga Practice. Many participants offered their own explanation for the benefits they accrued via yoga practice, such as growing awareness of the mind-body connection, improving breath regulation, taking

time to stop and slow down, and increasing confidence: "It really is more of a spiritual, emotional, and physical experience. I think that's what the yoga program provides that you aren't going to get anywhere else." Several participants reported how they noticed improvements in other aspects of their lives as a function of these mechanisms.

> *Yoga was the first time I realized I could lower my blood pressure by the way I breathed. I could take a breath and feel the stress drain away. The first time I saw that mind-body connection very clearly and I have used it actually quite often over the last three or four years.*

Many of the participants attributed improved breath regulation to physical and mental benefits.

> *I do have some lower back problems and I know I get tense. One thing I have learned to do is to breathe into those spots, which is how your get your muscles to relax. And I learnt that from the yoga program, nowhere else.*

Moreover, yoga improved participants' confidence, in their ability to not only practice yoga, but also engage in activities outside of the studio: "It has given me more confidence to stretch that out a bit in my own home, in another gym, things like that. I never would have joined that gym if I hadn't gone to the yoga program already." This notion of improved confidence came up several times in many different ways.

> *There was more confidence overall in myself. With confidence came an overall strength. It's the can do attitude that starts evolving from that as well. It's like a dominos thing - or a snowball really. It just keeps building and building and building. . ..*

Another participant agreed: "It was a sense that if I can do this yoga piece then I can do that home piece. If I can get up the stairs at the yoga studio I can get up the stairs at home, or if I am strong enough to do *this*, then I can do *that*." Through cultivating heightened awareness of the mind-body connection and psychophysiological self-regulation skills, participants developed the benefits of yoga both on and off the mat in activities of daily living.

While these proactive mechanisms by which participants posited the benefits of yoga accrued, it is important to note that, in many cases, participation in the yoga program by cancer survivors was motivated by fear.

> "For me, it's all about the mobility. I am really afraid. I still suffer from neuropathy, so I am just really afraid that if I stop I won't be able to move again. It' almost a fear-driven thing for me, besides the fact I've made friends . . . and I feel good when I do it. I feel energized when I leave. I mean there is lots of benefits, but I think the main reason is that I am always afraid I am not going to be able to move again if I don't continue."

In addition, another participant stated, "If there is anything I can do to stop any kind of recurrence, for my kind of cancer there is an 80% chance. . .. So if there is anything remotely, minute that could prevent that (recurrence), I am willing to try it. . . Maybe it's a fear driven thing? My mother ended up with four different kinds of cancer over her lifetime and I don't want that to happen to me. So maybe it is fear." Another survivor added, "This yoga helps me get through that because sometimes I am terrified. I am just terrified of what happens if this comes back. I am not afraid of dying. I am afraid of going through this again and it wasn't even that bad. But I don't want to go through this ever again."

Participants believed yoga practice benefits were derived from heightened awareness of the mind-body connection, breath regulation, better self-regulation, and improved self-confidence. However, in this sample, incentive to practice was also be related to coping with fear of worsening symptoms and cancer recurrence.

4. Discussion

Approaches to reduce the burden of cancer and its treatment for the growing population of cancer survivors are necessary. Self-management strategies, such as yoga, hold promise to allow individuals to regain control and manage their psychosocial and physical health [25]. Yoga has become more widely available within the cancer community as part of cancer treatment and recovery [11]. The impetus for the present qualitative study was to further explore cancer survivors and support persons' experiences of change over time and how self-perceived benefits are accrued via the phenomenological lens of the participants in the yoga program. This set of exploratory focus groups identified the following four key thematic areas of interest in a community-based yoga for cancer survivors program, including (1) safety and shared understanding; (2) cancer-specific yoga instruction; (3) benefits of yoga participation; (4) mechanisms of yoga practice.

The first theme, "safety and shared understanding," highlights the cancer-specific nature of the program provided feelings of safety and shared understanding. Cancer survivors and their support persons make deliberate choices to attend programs where there is a shared sense of meaning and collective understanding via the cancer experience [26]. Cancer-specific programs provide a place for survivors to engage in yoga with others who have also been affected by the disease. Previous literature suggests sharing a similar cancer diagnosis can create a sense of community that may alleviate of a sense of isolation commonly experienced by patients facing cancer [19]. In this study, shared practice conferred additional benefits independent of social support. Many participants iterated their appreciation for being able to engage in yoga within a cancer-specific program, highlighting the centrality of the yoga practice (and not their cancer) as important. Given yoga classes are experiential, with relatively little time devoted to talking and sharing amongst participants [17], a community-based yoga program not only may provide physical benefits, but also may provide an ideal avenue by which participants, who are not inclined to engage in social support groups, can have their social support needs met. This highlights the important role yoga may be able to play for cancer survivors; however, the relationship between the

cancer-specific aspects of the yoga class in conjunction with participants' shared experiences and the seemingly contradictory desire to distance oneself from a "cancer support" group is an area worthy of further exploration.

The second theme, "cancer-specific yoga instruction," suggests cancer survivors and their support persons not only view their cancer experience as unique but are aware and appreciate (1) that the yoga program is cancer-specific, (2) that the yoga instructors had appropriate, cancer-specific training, and (3) that the unique circumstances and symptoms of cancer survivors can be worked through in a collaborative fashion. A previous study conducted with breast cancer survivors found that a cancer-specific physical activity program was perceived as safe and supportive when the instructor was regarded as being trained and experienced in cancer and exercise [27]. However, the skills fostered within yoga practice are cultivated overtime and participants were appreciative of instructors' ability to meet participants where they were at in their cancer recovery and their corresponding levels of physical and mental fitness [28]. This included those new to yoga in need of more immediate modifications based on cancer treatment status or other functional limitations, as well as those participants who had established a yoga practice but were looking for additional instructional depth to facilitate their yoga experience. Moreover, similar to other qualitative work [17], the current findings suggest that the instructor played a central role in many of the benefits accrued (e.g., confidence). This came from learning yoga within a safe and supportive environment comprising positive interactions with instructors and fellow yoga participants.

The third theme, "benefits of yoga participation," underscores the multitude of benefits participants achieve from engaging in yoga practice, from stress reduction and relaxation to physical health promotion, social-emotional regulation, and improved quality of life. Similar to work by McCall et al. [19] yoga was reported by participants as a means to encourage personal navigation of the cancer experience. Participants (survivors and support persons) indicated that participation in the community-based yoga program was a respite both during and following cancer treatment. Cancer survivors suggested yoga practice leads to a heightened sense of self-awareness and empowerment during a difficult disease and treatment course and in time of increased distress and uncertainty. Moreover, yoga served as a means to better self-regulate and manage symptoms including pain, fatigue, and sleep disturbances. Generally, the psychosocial and physical benefits reported were similar to those reported in recent systematic reviews and meta-analyses [10, 11]. The results therefore extend previous findings that yoga exerts positive health benefits for cancer survivors. However, in addition to confirming some of the psychosocial and physical benefits reported by recent reviews, this study also provides evidence that yoga may promote outcomes that have been studied less frequently, including relaxation and mental health.

Despite the reported benefits, it is important to temper these findings per the focus group discussions. Namely, that these benefits were accrued over time and cancer and its treatment posed significant barriers to attaining these benefits. This has implications for how yoga programs are presented and discussed with cancer survivors. Explaining that change is a process and benefits accrued may vary depending on treatment status may better prepare cancer survivors for participating in a yoga program and for their outcome expectations. Finally, while participants felt yoga practice aided in their cancer recovery, they by no means felt it was a remedy for all their ills. Many participants indicated they were also engaging in a range of other self-management strategies, while others indicated they felt better as they recovered as a function of time since treatment. This could indicate that yoga may be an invitation to other self-management strategies or vice versa. While more studies are needed to evaluate the effects of yoga on these outcomes, this study provides preliminary evidence that yoga may be a useful self-management strategy to promote facets of psychosocial functioning, within the context of survivorship.

The fourth theme, "mechanisms of yoga practice," suggests cancer survivors and their support persons are acutely aware of the process by which the benefits they accrue from yoga practice are derived. The mechanisms participants reported were similar to those that have been reported previously in studies exploring yoga with cancer survivors (i.e., awareness of the mind-body connection, ability to regulate breath, and enhanced confidence; [21, 29]). However, in addition to these yoga-specific elements, participants also described intrinsic motivations as a contributor to the benefits obtained. This sense of regaining control has been evidenced in other qualitative research [18], suggesting participants may benefit from engaging in self-directed practices, which allow them to take an active role in their cancer recovery. This mirrors research conducted in the broader physical activity literature that has found self-determined motivations to be strongly associated with psychological outcomes [30–32].

Extending work by van Uden-Kraan et al. [16], participants felt their participation in yoga contributed to their own cancer rehabilitation process. However, this mechanism was tempered with participant fears of worsening symptoms and cancer recurrence [33], as this was a strong motivator for beginning and continuing engagement in the yoga program. There is no consensus on the definition of "fear of recurrence," but many suggest it is the "fear that cancer could return or progress in the same place or in another part of the body [34]." Fear of cancer recurrence is one of the most commonly reported emotional effects of cancer [35], with the majority of studies finding that fear of cancer recurrence is one of the most consistently reported unmet needs [36]. Interventions are only recently being developed and delivered (e.g., counseling, cognitive-behavioural therapy) to target fear of cancer recurrence. A recent systematic review found few trials and mixed results for intervention efficacy [37]. Participants' experiences in this study therefore highlight several important avenues for future researchers, such as examining if yoga mitigates or tempers fears of recurrence and exploring individual differences in fear of recurrence as a motivator to engage in yoga.

4.1. Strengths and Limitations. In contrast to previous yoga studies that have focused on breast cancer survivors, this

study included mixed cancer survivors and their support persons. The inclusion of a heterogeneous sample ensured multiple perspectives were included. In addition, this study included a relatively large sample size for qualitative research. The use of a qualitative research approach in conjunction with inductive thematic analyses across 10 focus groups over a period of six months provided a unique analyses of how yoga practice in a community setting is perceived by cancer survivors and their support persons. Thus, these findings extend previous research, but also provide novel information identifying potential mechanisms underpinning the benefits accrued, highlighting the complexities of participating in yoga in the context of survivorship, and provide an in-depth understanding of participation in a community-based yoga program. This study lays a foundation in the aid of creating stronger yoga research evidence and heightened clinical practice for those facing cancer.

Despite these distinct advantages, this study is associated with several limitations that should be considered. Inherent within qualitative methodology, findings cannot be generalized beyond this group of informants, who are unique in their diagnoses, backgrounds, and personal histories. Rather qualitative studies of this nature can be used to generate hypotheses rooted in firsthand experiential data of how cancer survivors perceive their experience of yoga and the role it may play in their lives. In addition, the average participant in the qualitative component of this study had taken the program three or more times. This constitutes a unique group of cancer survivors, many of whom had ample yoga experience. Given this familiarity with yoga practice the benefits of practice they describe may not be achievable in those who practice for a shorter duration. Given the heterogeneity of cancer types and duration of practice, a dose-response relationship may also be important to explore [38]. However, these findings are consistent with other qualitative and quantitative research findings in both yoga and physical activity research, which enhance confidence in the suggested benefits and associated mechanisms of action.

5. Conclusions

Participants shared their collective experience of yoga practice as cancer survivors and support persons. The present study generated significant contextual knowledge about the role of yoga within cancer survivors lives over the course of several months within a real cancer care setting. In general, the present qualitative findings suggest yoga was an important component of survivorship aiding cancer survivors in their cancer journey and provided respite during active treatment. Participants in the current study experienced yoga practice as beneficial combining tailored methods of self-regulation within a socially supportive safe environment that was focused on yoga practice instead of "cancer." Further research is needed to further explore these preliminary findings for yoga practice within community-based cancer care settings. It is suggested that continued qualitative research or mixed methods research methodologies be utilized in to better understand and explore participants lived experience of yoga and how these practices become integrated into their lives. Given the diverse benefits and posited mechanisms, more structured research will further identify the beneficial aspects of yoga within a socially supportive environment. These findings may inform future directions of research, providing a rich phenomenological source from which further questions and theories can emerge concerning those who practiced yoga in tandem with mainstream cancer treatments.

Competing Interests

The authors declare that they have no competing interests.

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Research Article

Physical-Performance Outcomes and Biomechanical Correlates from the 32-Week Yoga Empowers Seniors Study

Man-Ying Wang,[1] Gail A. Greendale,[2] Sean S.-Y. Yu,[1] and George J. Salem[1]

[1]*Division of Biokinesiology and Physical Therapy, University of Southern California (USC), 1540 E. Alcazar Street, Los Angeles, CA 90033, USA*
[2]*Division of Geriatrics, Geffen School of Medicine, University of California, Los Angeles (UCLA), 924 Westwood Boulevard, Suite 200, Los Angeles, CA 90024, USA*

Correspondence should be addressed to George J. Salem; gsalem@usc.edu

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Background. Yoga Empowers Seniors Study (YESS) quantified physical demands associated with yoga performance using biomechanical methods. This study evaluated the efficacy of the program on physical function outcomes. *Methods*. Twenty community-dwelling older adults aged 70.7 ± 3.8 years attended biweekly 60-minute Hatha yoga classes for 32 weeks. Four domains of the physical measurements including (1) functional performance, (2) flexibility, (3) muscle strength, and (4) balance were taken at the baseline, 16-week and 32-week time points. Repeated-measures ANOVA omnibus tests and Tukey's post hoc tests were employed to examine the differences in each outcome variable across the 3 time points. *Results*. Improved timed chair stands ($p < 0.01$), 8-foot up and go ($p < 0.05$), 2-min step test ($p < 0.05$), and vertical reach ($p = 0.05$) performance were evident. Isometric knee flexor strength ($p < 0.05$) and repetitions of the heel rise test ($p < 0.001$) also increased following the 32-week intervention. Both flexibility and balance performance remained unchanged. *Conclusions*. Significant improvements in physical function and muscle-specific lower-extremity strength occur with the regular practice of a modified Hatha yoga program designed for seniors. These adaptations corresponded with the previously reported biomechanical demands of the poses.

1. Introduction

In the past decade, yoga participation by community-dwelling older adults has continued to rise, increasing from 1.3% in 2002 and 2.0% in 2007 and accelerating to 3.3% in 2012 [1, 2]. Despite its popularity, little is known about the biomechanical demands of yoga participation by seniors or the physical adaptations that occur in association with these demands; thus, the YESS (Yoga Empowers Seniors Study) study was designed to answer these questions. Previous YESS papers have addressed the methodological design of the study and quantified the physical demands of the program poses biomechanically [3–6]; here we report the adaptations in (1) functional performance, (2) flexibility, (3) muscular strength, and (4) balance, following the 32-week modified Hatha yoga program designed specifically for ambulatory older adults.

To date, investigations related to the effects of yoga on physical function, particularly in this cohort, are not conclusive. For example, Chen's group developed the *Silver Yoga* program for seniors and found improved outcomes in functional measures including chair stands, walking speed, and upper- and lower-extremity flexibility, following 24 weeks of yoga participation by older adults (age 69 ± 6.3 yrs) [7]. Similar benefits were also found in assisted-living frail elders and seniors with dementia [8, 9] by the same group of investigators. In addition to improved mobility and flexibility outcomes, beneficial effects of yoga on muscle strength, balance, and fear of falling have also been demonstrated in senior participants in previous studies [10–12]. Unfortunately, these optimistic findings are not consistent across studies. For example, Oken et al. [13] reported that mobility measures including chair stands and timed walking performance did

not improve after yoga participation in healthy seniors although enhanced lower-extremity flexibility and balance were evident. Contrastingly, no significant changes in total balance score, fear of falling, flexibility, or quality of life, were found in studies reported by Schmid et al. and Saravanakumar et al. [14, 15].

Several factors such as participant age, physical status, and prior yoga experience and study design including the intervention duration and testing methodology are likely to have contributed to these contradictory findings. The amount of information regarding program design varied greatly across these reports: some only included a list of poses [10, 11, 14]; some provided detailed information of pose progression [15, 16]; some included pose illustrations [12, 17]; others described the programs without pose details [7–9, 13, 18].

Most importantly, none of these prior studies [7–15, 17, 18] quantified the physical demands (joint range of motion, joint moments of force, or muscle activation patterns) of the yoga poses, making it difficult to interpret the mixed results or extrapolate the findings across cohorts. Understanding the links between these physical demands (stimuli) and the participant's physical-performance changes (adaptations) provides a window through which we can begin to appreciate yoga's *mechanisms of action* and allows future yoga instructors and investigators to refine the program in order to maximize its beneficial effects. Put simply, quantifying the stimuli that the body experiences during each pose is one way to decipher why some postures "work" (i.e., in this framework, result in better strength, flexibility, and/or balance) while others do not.

In this study, we adopted a standardized, quantified yoga program, a 32-week yoga intervention program specifically designed for community-dwelling seniors [3]. The aim of this report was to quantify the physical-performance changes, including (1) functional performance, (2) strength, (3) flexibility, and (4) balance, following the yoga intervention. These physical-performance changes are further discussed qualitatively in the context of our reported biomechanical findings measured in the same testing sessions that the final physical function measurements occurred.

2. Methods

2.1. Study Design. YESS was a single-arm, 32-week, pre-post, intervention-development study. The aims of the study were to quantify both the physical demands of the yoga poses used in the program and the physical-performance adaptations that occurred following the 32-week intervention. The yoga program consisted of 2 phases: a 16-week beginning phase (*Series I*) and a 16-week advanced phase (*Series II*) [3]. The program was designed to be suitable and practical for ambulatory older adults. Anthropometric measurements as well as measures of (1) functional performance, (2) flexibility, (3) muscle strength, and (4) balance were taken at baseline and after each phase of the yoga intervention (a total of 3 measurement sessions: 0 weeks, 16 weeks, and 32 weeks). Data collection was conducted at the Musculoskeletal Biomechanics Research Laboratory (MBRL) at the University of Southern California (USC). Subject recruitment and the yoga classes were conducted at the University of California Los Angeles (UCLA) and TruYoga studio (Santa Monica, CA), respectively. The USC and UCLA Institutional Review Boards approved the study protocol and all participants provided informed, written consent.

2.2. Subjects. Community-dwelling older adults, aged 65 years and older, were recruited from the West Los Angeles area via mailing lists, physician referrals, flyers, websites, and newspaper advertisements. Potential subjects were screened via a telephone interview that assessed demographic information, location of residence, transportation capability, and current medical conditions. In order to decrease potential cardiovascular, musculoskeletal, and neurological risks to the participants, related safety exclusions were adopted [3, 4]. Participants also had to execute the following safety tests stably and independently: transition from standing to recumbent on the floor and reverse; lifting both arms to shoulder level; standing with feet side-by-side for 30 seconds; and standing with feet hip-width apart for 60 seconds.

Twenty-four subjects passed the screening exam, were enrolled in the study, and completed the baseline measurements. Twenty of these participants went on to complete the 32-week program and the 2 follow-up assessments (at 16 weeks and 32 weeks). Of the 4 participants who did not complete the intervention, 2 deemed that the time commitment was too great, 1 had recurring posterior thigh pain following the baseline visit (prior to the yoga classes), and one experienced low back pain during the yoga classes (left the study at week 14). The mean percentage of the yoga class attendance over the intervention period was 83% (85.4% ± 7.6% and 80.3% ± 13.2% for *Series I* and *Series II*, resp.). The average age of the 20 participants (6 males and 14 females) was 70.7 ± 3.8 years. Their average height, weight, and body mass index at baseline were 1.67 ± 0.07 m, 71.3 ± 14.6 kg, and 25.3 ± 4.1 kg/m^2, respectively.

2.3. Yoga Program. The program was an adapted form of Hatha yoga that incorporated asanas and *pranayama* (breathing) [19]. It was developed by a research team which included an experienced yoga therapist (EYT-500), a geriatric physician, an exercise physiologist/biomechanist, and a physical therapist. The yoga classes were 60 minutes per session including warm-up and cool-down periods. Classes were held 2 times per week for a total of 32 weeks. Two series of poses, *Series I* and *Series II*, were trained in sequence, each for 16 weeks.

The series were designed to be progressive in nature (i.e., advancing in difficulty) and to train the major muscle groups that are integral to the performance of activities of daily living. The poses for *Series I* included the Chair, Wall Plank, Tree, Warrior I, Warrior II, Downward Facing Dog, Side Stretch, Cobra, Bridge, and Abdominal Cultivation. These classic poses were modified to accommodate the reduced strength, flexibility, and balance capabilities of the senior participants. Modifications included the use of chairs, blocks, and walls, for support. The poses for *Series II* included Chair,

Wall Plank, Tree, Warrior II, Side Stretch, Crescent, One-Legged Balance, Recumbent Leg Stretch, Bridge, and Abdominal Cultivation. Poses in *Series II* were performed with fewer modifications, relative to the poses in *Series I*. Additionally, opening (warm-up) poses and finishing (cool-down) poses were incorporated in both series. Detailed pose descriptions and specific modifications, including photos, can be found in a separate report [3]. The report is Open Access and can be viewed via the following links. For the *Series I* poses, see https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3639444/table/T1/. For the *Series II* poses, see https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3639444/table/T2/. Information of the opening and finishing poses are also included in both links. The physical-demand profiles of these poses were detailed in another Open Access paper [4] (https://www.ncbi.nlm.nih.gov/pubmed/24282431).

2.4. Measurements. Measurements included tests of (1) functional performance, (2) flexibility, (3) muscle strength, and (4) balance. All measurements were collected at the baseline, at the *Series I* follow-up (16 weeks), and at the *Series II* follow-up (32 weeks).

2.4.1. Functional Performance. Functional performance measurements/tests included (a) timed chair stands, (b) 8-foot up and go, (c) 2-minute step test, (d) horizontal reach, and (e) vertical reach. The timed chair stands test records the number of seconds it takes to stand up 5 times from a chair without using hands [20]. It is an assessment of lower-extremity strength and power and is associated with fall risk and the development of functional dependence [21]. The Intraclass Correlation Coefficient (ICC[2, 1]) between weekly measurements for this test in healthy older adults 51–78 years is 0.85. The 8-foot up and go test measures the time it takes for a subject to get up from a chair, walk as quickly as possible around a cone located 8 feet away, return to the chair, and sit down [22]. It assesses agility and dynamic balance and is significantly related to Berg Balance Scale performance, gait speed, and the Barthel Index of ADLs [23]. Performance is also associated with fall risk in older adults [24]. The test-retest reliability for this test in our lab is excellent (ICC[2, 1] = 0.95). The 2-minute step test quantifies the number of times that a subject can step in place within 2 minutes [22]. This test measures lower-extremity muscular endurance and is significantly correlated with maximum aerobic capacity, 1-mile walk performance, Balke graded treadmill test, and quality of life [25–28]. The test-retest reliability ICC within our lab is 0.90 in healthy older adults. The maximum horizontal reach test, often referred as functional reach performance, records the maximum forward distance a participant can reach while keeping both feet on the floor [29]. This test evaluates upper- and lower-extremity flexibility, lower-extremity strength, and balance. In order to administer this test, reflective markers were placed on the 3rd metacarpal head. To quantify maximum horizontal reach, the marker position was recorded with an 11-camera motion capture system (Qualisys; Gothenburg, Sweden) while the participant reached forward as far as possible while keeping both feet in contact with the floor. The marker distance from the standing position with the measured arm parallel to the floor to the maximum reach point was calculated and averaged across the 3 trials. This test is significantly correlated with walking speed, social mobility, single-leg standing balance, and fall risk [30, 31]. The maximum vertical reach test which assesses the maximum height a participant can reach during standing was conducted using standard procedures [16]. Similar to the maximum horizontal reach test, the test was measured by tracking the position of the 3rd metacarpal head reflective marker with the motion capture system while the participant reached vertically as high as possible and their feet remained flat on the ground. The highest position of the hand marker was calculated and averaged across 3 attempts. The test-retest reliability for this test is excellent (ICC[2, 1] = 0.99) in our laboratory.

2.4.2. Flexibility. Upper- and lower-extremity flexibility were assessed using (a) back scratch and (b) chair sit and reach tests. The back scratch test examines the combined range of motion of the upper-extremity joints in a standing position. Subjects were asked to reach posteriorly with both arms (one superior and other inferior) and attempt to touch or cross their middle fingers across their back [22]. The average distance of overlap (positive value) or distance between the tips of the middle fingers (negative value) across 3 trials was recorded.

The chair sit and reach test assesses upper-extremity (UE), trunk, and lower-extremity (LE, primarily hamstrings) flexibility [22]. Subjects were asked to sit on the edge of a chair with one knee bent at a 90-degree angle (foot flat on the floor), and the other knee extended as straight as possible. Subjects then slowly flexed their trunk and reached forward as far as possible, along their extended limb with overlapped middle fingers. The average distance from the tips of their middle fingers, to the top of their shoe, across 3 trials was recorded.

2.4.3. Muscular Strength and Performance. Muscle strength measures were taken from the following muscle groups of the dominant limb: (a) elbow flexors, (b) elbow extensors, (c) knee flexors, (d) knee extensors, (e) hip abductors, and (f) ankle plantar-flexors. For the elbow and knee muscles, strength was quantified isometrically using the Cybex Norm with HUMAC (CSMi, Stoughton, MA, USA). Standardized testing procedures provided by the manufacturer were employed and standard verbal encouragements were provided. A rest period of 20 seconds was given to the subjects between trials. Subjects practiced 1 warm-up trial and then performed a total of 3 trials for each muscle group. Peak torque during each trial was then recorded and averaged across the trials. Isometric hip abductor strength was measured using the *MicroFET 2 hand held dynamometer* (Hoggan Health Industries, Inc., Draper, UT). Subjects were positioned lying on their side, on an examination table, with their knee and hip extended. A hip strap was placed across the iliac crest to stabilize the pelvis. The dynamometer transducer pad was placed 5 cm proximal to the lateral femoral condyle of the dominant leg (the leg with which they would kick a ball). Subjects were instructed to exert their maximum effort for 5 seconds, 3 times, with 15 second rest intervals between

Table 1: Results for functional performance and flexibility tests ($n = 20$).

Measurement	Baseline (T_1)	16 weeks (T_2)	32 weeks (T_3)	$F1$ (p)[a]	Post hoc[b]	
					% change T_1–T_3[c]	% change T_2-T_3[d]
Functional performance						
Timed chair Ssand (sec)	12.1 ± 2.3	11.7 ± 2.2	11.1 ± 2.4	5.49 (0.008)	−7.8%**	−4.6%ns
8-foot up and go (sec)	5.2 ± 0.9	5.4 ± 0.9	4.9 ± 0.9	4.79 (0.014)	−5.2%ns	−8.2%**
2 min step (rep.)	75.1 ± 16.7	81.7 ± 17.2	83.7 ± 18.0	3.37 (0.045)	13.3%*	3.8%ns
Vertical reach (cm)	202.0 ± 10.4	202.0 ± 10.3	203.1 ± 10.5	3.20 (0.052)	0.3%**	0.3%**
Horizontal reach (cm)	33.3 ± 5.8	34.0 ± 4.7	34.8 ± 5.2	0.80 (0.455)	—	—
Flexibility						
Back scratch (cm)	−5.8 ± 10.1	−5.7 ± 9.4	−4.5 ± 8.9	1.68 (0.201)	—	—
Sit and reach (cm)	−3.9 ± 10.8	−6.1 ± 11.2	−2.5 ± 9.9	2.99 (0.063)	—	—

[a]F and p values from repeated-measure ANOVA omnibus tests.
[b]Measurement time points at baseline (T_1), 16 weeks (T_2), and 32 weeks (T_3). No significant differences between T_1 and T_2 were found in all measurements with a significant F value. ns = nonsignificant; — = post hoc analysis was not performed because of nonsignificant F value.
[c]Percent change was calculated as an average of individual's percent change between T_1 and T_3.
[d]Percent change was calculated as an average of individual's percent change between T_2 and T_3.
*$p < 0.05$.
**$p < 0.01$.

efforts. The peak value during each trial was recorded and averaged across the 3 trials. Ankle plantar-flexor strength and endurance were assessed by quantifying the number of successful heel rise cycles the subject could perform, while standing on the dominant limb, at a speed of 0.5 Hz [32, 33]. Subjects were instructed to rise up onto their toes (plantar-flex their ankle) as many times as possible, to the beat of the metronome (0.5 Hz). The participant was allowed to touch the examiner with a single finger for balance. The test was terminated when the subject (1) failed to lift their heel pass the target mark (1/2 maximum plantar-flexion distance), (2) flexed their knee, (3) requested to stop, or (4) was no longer able to match the movement speed provided by the metronome. Only one trial was administered for this test.

2.4.4. Balance. Balance performance was assessed under the following conditions: (a) double-limb standing with eyes open, (b) double-limb standing with eyes closed, and (c) single-limb standing with eyes open conditions [34–36]. Subjects were requested to stand "quietly" and keep as still as possible, for 2 consecutive 20-second trials in each condition [37]. The tests were ended when the subject moved their feet during double-limb standing tests or touched the ground with their contralateral limb during single-limb standing test. The number of the seconds the subject could perform each task was recorded. If a participant successfully stood for 20 seconds without losing balance, the score was 20 seconds. The average time, across the 2 trials within each condition, was recorded.

2.5. Data Analysis. Muscle strength data was normalized to body weight. The differences in each outcome variable among the 3 time points were then examined using repeated-measures ANOVA omnibus tests. When a significant difference was identified, Bonferroni's post hoc tests were used to examine the pairwise comparisons. For all statistically significant post hoc comparisons, Cohen's d effect sizes (small $d = 0.2$; medium $d = 0.5$; large $d = 0.8$) are also reported [38]. Statistical analysis was conducted via PASW Statistics 18 (IBM SPSS Statistics, Armonk, NY) and p values < 0.05 are considered statistically significance.

3. Results

3.1. Anthropometrics. Following the 32-week intervention, body weight and body mass index remained unchanged. Body height increased significantly by 0.3% (an average of individual difference = 0.6 cm; $p < 0.05$).

3.2. Functional Performance. Results from the repeated-measure ANOVA indicated that timed chair stands ($p < 0.01$), the 8-foot up and go ($p < 0.05$), and the 2-min step test ($p < 0.05$) improved between baseline and follow-up measures (Table 1). A post hoc analysis indicated that the subjects significantly improved timed chair stand performance by 7.8% from the baseline to the 32-week time point ($p < 0.01$, $d = 0.43$). There was an 8.2% improvement in 8-foot up and go performance from week 16 to week 32 ($p < 0.01$, $d = 0.56$). For the 2-min step test, subjects increased by an average of 8.6 repetitions (13.3%) following the 32-week intervention ($p < 0.05$, $d = -0.50$). For the vertical reach, the ANOVA test revealed a borderline significance ($p = 0.05$). When the post hoc analysis was further conducted, results demonstrated that the vertical reach height remained unchanged between baseline and week 16. At the 32-week time point, there was a significant increase (0.3%) in vertical reach height compared to the baseline and the 16-week time points ($p < 0.001$ and $p < 0.001$, resp.). These findings, however, presented with small effect sizes ($d = -0.11$ and -0.11, resp.). There were no significant changes in horizontal reach performance ($p = 0.46$).

3.3. Flexibility. There were no significant changes in back scratch test and chair sit and reach test results over time, as

Table 2: Results for lower-extremity muscle strength tests ($n = 20$).

Strength measure	Baseline (T_1)	16 weeks (T_2)	32 weeks (T_3)	$F1$ (p)[a]	Post hoc[b]	
					% change T_1-T_2[c]	% change T_1–T_3[d]
N elbow flex (Nm/kg)	0.6 ± 0.2	0.6 ± 0.2	0.6 ± 0.2	0.70 (0.506)	—	—
N elbow ext (Nm/kg)	0.5 ± 0.2	0.5 ± 0.2	0.5 ± 0.2	2.14 (0.132)	—	—
N knee flex (Nm/kg)	0.8 ± 0.3	0.9 ± 0.3	1.0 ± 0.4	3.61 (0.038)	15.6%[ns]	35.8%[*]
N knee ext (Nm/kg)	1.5 ± 0.5	1.5 ± 0.4	1.6 ± 0.5	0.89 (0.418)	—	—
N hip abd (Nm/kg)	2.6 ± 0.7	2.8 ± 0.5	2.8 ± 0.7	3.14 (0.056)	—	—
Heel rise (rep.)	21.0 ± 7.0	25.2 ± 6.1	28.3 ± 5.7	11.75 (0.000)	29.9%[*]	45.9%[**]

N = normalized muscle strength to body weight.
[a]F and p values from repeated-measure ANOVA omnibus tests.
[b]Measurement time points at baseline (T_1), 16 weeks (T_2), and 32 weeks (T_3). No significant differences between T_2 and T_3 were found in all measurements with a significant F value. ns = nonsignificant; — = post hoc analysis was not performed because of nonsignificant F value.
[c]Percent change was calculated as an average of individual's percent change between T_1 and T_2.
[d]Percent change was calculated as an average of individual's percent change between T_1 and T_3.
[*]$p < 0.05$.
[**]$p < 0.001$.

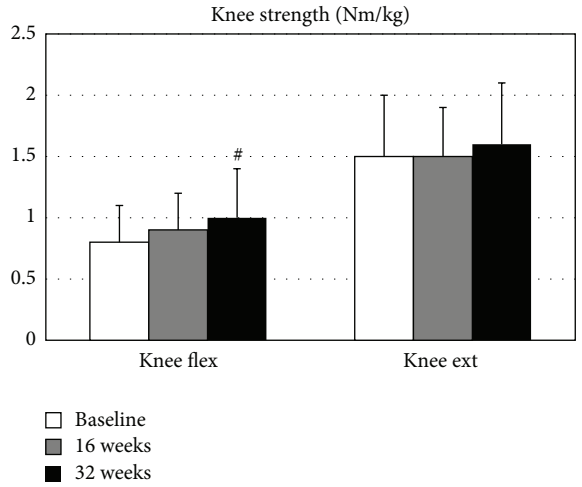

Figure 1: Normalized knee muscle strength. [#]Significantly different from the baseline, $p < 0.05$.

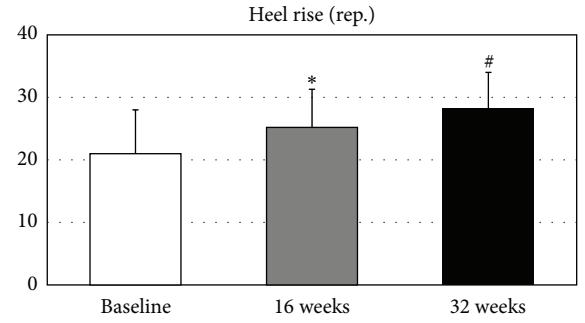

Figure 2: Ankle plantar-flexor strength and endurance. [*]Significantly different from the baseline, $p < 0.05$. [#]Significantly different from the baseline, $p < 0.001$.

indicated by the repeated-measure ANOVA tests ($p = 0.20$, and 0.06, resp., Table 1).

3.4. Muscle Strength. The repeated-measure ANOVA tests demonstrated significant improvement between baseline and follow-up measures for isometric knee flexor strength ($p < 0.05$, Table 2) and the heel rise test ($p < 0.001$). Knee flexor strength increased by 35.8% after 32 weeks of yoga intervention ($p < 0.05$, $d = -0.57$, Figure 1). Likewise, compared to the baseline measures, heel rise performance improved by 29.9% ($p < 0.05$, $d = -0.64$) at week 16 and 45.9% ($p < 0.001$, $d = -1.14$) at week 32 (Figure 2). There were no significant changes found in normalized strength of the elbow flexors ($p = 0.51$), elbow extensors ($p = 0.13$), knee extensors ($p = 0.42$), or hip abductors ($p = 0.06$).

3.5. Balance. All subjects were able to stand using both feet (double-limb standing) for the maximum amount of time (20 seconds), with eyes closed and eyes open, at the baseline, 16- and 32-week time points. The average duration of single-limb standing with eyes open at the baseline was 14.5 ± 4.7 seconds. The yoga intervention did not significantly change single-limb standing time ($p = 0.41$).

4. Discussion

Hatha yoga is an increasingly popular physical activity adopted by seniors, in part because it is believed to improve and/or preserve physical function. Previous reports on the effects of yoga participation on physical function in seniors have been equivocal and the lack of information regarding the physical demands of these various programs makes it difficult to interpret these conflicting findings. Here we report the physical adaptations, including functional performance, flexibility, muscle strength, and balance, which occurred following a 32-week modified Hatha yoga intervention for seniors. Additionally, we use our previous YESS biomechanical findings, acquired at the same time as the final physical function measurements (32-weeks), to qualitatively interpret our results. The possible clinical implications of the results were summarized in Table 3.

4.1. Functional Performance and Flexibility. Functional tests are integrated measures of LE and UE strength, balance,

Table 3: Possible clinical implications of the findings in physical adaptations following a 32-week Hatha yoga intervention for seniors.

Measurements	Significant improvement[a]	Possible clinical implication
Functional performance		
Timed chair stand	Mild	↑ ADL independence
		↑ gait speed
		↓ disability
		↓ risks of falls
8-foot up and go	Moderate	↑ ADL independence
		↑ balance
		↑ gait speed
		↓ risks of falls
2 min step	Moderate	↑ aerobic capacity
		↑ gait speed
		↑ quality of life
		↓ risks of falls
Vertical reach	Very mild	↑ ADL independence
Horizontal reach	None	No effect
Strength measures		
Elbow flexor	None	No effect
Elbow extensor	None	No effect
Knee flexor	Moderate	↓ incidence of falls
		↓ LE disability
Knee extensor	None	No effect
Hip abductor	None	No effect
Heel rise	Major	↑ ADL independence
		↑ gait speed
		↓ risks of falls
Flexibility		
Back scratch	None	No effect
Sit and reach	None	No effect
Balance		
Single/double limb standing with eyes open/closed	None	No effect

↑ = increase; ↓ = decrease; ADL = activities of daily living; LE = lower-extremity.
[a]Significant improvement after 32 weeks of intervention is categorized by Cohen's d effect sizes (mild = $d > 0.2$; moderate = $d > 0.5$; major = $d > 0.8$). None = no statistically significant improvement was found.

flexibility, speed, power, and reaction time. While each test focuses on specific physical domains (e.g., LE muscular endurance; plantar-flexion function), better performance generally reflects an individual's capacity to accomplish daily living activities, which are paramount to the preservation of independent living [39]. In the current study, the time needed to stand from a chair 5 times dropped by 1 second, a statistically and clinically significant 7.8% improvement, from baseline to the 32-week mark. This finding agrees with results from two recent randomized controlled trials; an 8 wk, 3 d/wk, Hatha yoga study in sedentary adults (age 62.1 ± 5.8 yrs) [10] and a 12 wk, 2 d/wk Iyengar yoga study in community-dwelling seniors (age 67.7 ± 7.2 yrs) [12]. Both studies showed significant improvements in chair stand performance compared to the controls. The chair stands test is significantly correlated with knee strength, walking speed, and lean and fat mass of the LE and UE in independently ambulatory older adults (1,263 women and 1,221 men; aged 70–80 years) [40]. In contrast, slower chair stands time is associated with decreased physical activity level, disability, a history of falls, lower bone mineral density, and fractures [39, 41, 42]. And, not being able to complete this task within 12.9 sec increases the probability of peripheral bone fracture by 2-fold in middle-age women (age 55.1 ± 9.6 yrs, $n = 484$) [39]. Expanding upon this, Khazzani et al. reported that for every 1-second increase in 5 chair stand time, there is a 4% increase in the number of falls per year [39]. Although the rates of falls were not monitored in the current study and our subjects were older compared to Khazzani et al.'s study, the 1.0 sec improvement, from 12.1 sec to 11.1 sec, after the 32-week intervention in the current report, may imply a protective effect against falls. This amount of change approximates to an age difference of 10 years (younger) in normative cross-sectional data by a national survey ($n = 5{,}403$; age > 60 yrs) [43]. Surprisingly, improvement in timed chair stands performance was not accompanied with changes in quadriceps muscle strength (discussed below), suggesting that other mechanisms (e.g., improved hip extension or ankle plantar-flexion strength, which we observed) may be responsible for this functional improvement.

Participants improved their timed up and go performance by an average of 8.2% between weeks 17–32; however, there was no improvement during the first 16 weeks of yoga practice. These findings suggest that inclusion of the more physically demanding *Series II* poses (which occurred between weeks 17–32) [4–6] is likely necessary to induce improvements in this functional test. The 8-foot up and go test is one of the standard assessments in the Senior Fitness Test developed by Rikli and Jones [22]. In Khazzani et al.'s study, this test, in addition to the timed chair stands test, was a significant predictor of the number of falls per year after adjusting for age [39]. The relative risk was 1.03 falls per one-second increase in timed performance. Moreover, balance, walking speed, and the performance of daily living activities are all correlated with this measure [23, 24]. In the current study, the average individual improvement of the timed up and go test was 0.5 sec. When referencing to the normative cross-sectional data in seniors employing the same standard test, an age difference of 5–10 years (younger) is noted with 0.5 sec difference in performance [22].

In the 2-minute step measure, performance improved by an average of 8.3 repetitions (13.3%) at 32 weeks. This test is a practical field test of aerobic capacity in seniors [28]. Compared to walking test, it requires a greater amount of single-limb support time due to the fact that subjects have to lift their knee above a specified target height (midpoint between the patella and iliac crest). As a result, not only endurance (both muscular and pulmonary) but also balance is assessed. Validations of this step test against cardiopulmonary assessments included maximum aerobic capacity,

1-mile walk test, and Balke graded treadmill test [26, 27]. The measure was also found significantly related to balance performance and risk of falls [44, 45]. The normative cross-sectional data of this 2-min step test were previously reported [22] and with similar amount of improved performance to the current study, an age difference of approximately 15 years (younger) was demonstrated by the cross-sectional data.

A small but statistically significant increase of 0.3% (0.6 cm) in vertical reach distance was observed after 32 weeks. Vertical reach performance is affected by UE and trunk range of motion and strength, balance capabilities, and fear of falling. We did not find changes in the back scratch or sit and reach tests which also test UE flexibility. Thus, we do not believe that increased reach performance occurred because of UE flexibility changes. Unfortunately, the YESS methodology did not include individual measures of trunk flexibility or fear of falling; thus, teasing-out the mechanism underlying the vertical reach improvements is a challenge. While stretching is an important component of yoga pose performance, results are mixed in the literature regarding yoga's effects on flexibility in older adults [7, 8, 15]. Chen and her coworkers developed a 70-min, 3 times per week Silver Yoga program for elders [7, 8, 46]. The summary of their work suggested that improved shoulder range of motion was observed as early as 4 weeks of yoga intervention. The changes in sit and reach performance, however, were not conclusive until 24 weeks of training. On the other hand, after 12 weeks of 75 min, twice weekly, yoga participation, Schmid and colleagues demonstrated no changes in either back scratch or sit and reach performance [15]. Our findings are consistent with Schmid et al.'s report. Factors such as age, initial strength and flexibility, duration of training, program adherence, testing protocols, and asana selections could all affect the results. Our yoga program included many yoga poses that were also incorporated in Schmid et al.'s study, for example, Mountain, Tree, Chair, Warrior I, Warrior II, Side Stretch, and Chair Twist. This comparison was made possible because detailed yoga programs were provided in both studies. Because similar poses were practiced in both studies by similar cohorts, we are not surprised to find comparable results across the two studies. Conversely, details of the Silver Yoga program conducted by Chen's group were not published, making explanations for the result discrepancies difficult to interpret.

4.2. Strength and Muscular Performance. Of the 6 muscle performance assessments (elbow flexion/extension, knee flexion/extension, hip abduction, and ankle plantar-flexion), only knee flexion strength and ankle plantar-flexor performance improved after the intervention. Knee flexor strength declines approximately 11% in men and 8% in women, per decade [47]. The 35.8% (0.2 Nm/kg) improvement in knee flexor strength experienced after 32 weeks in the current study was similar to the strength loss that occurs across 2 decades in this age group, according to previous cross-sectional data [47, 48]. Improved knee flexor strength has also been reported to be associated with a reduced incidence of falls in older women [49] and reduced pain and disability in seniors with knee osteoarthritis [50].

Participants also increased their plantar-flexion (heel rise) performance by 45.9% (7.1 repetitions) between the baseline and 32 weeks. With aging, older adults can lose plantar-flexor strength by up to 15% per year after being adjusted for muscle cross-sectional area, physical activity, and gender [51]. Plantar-flexor performance is statistically significantly associated with functional limitations [52], walking speed [53], and risk of falls [54] in community-dwelling seniors. Almost 50% of improvement in plantar-flexion performance in the present study corresponded well with our biomechanics findings collected with the same group of participants at the 32-week point [4, 5], where we reported that *all* of the poses in the yoga program (both *Series I and Series II*) generated internal ankle plantar-flexor joint moments and that none of the poses generated dorsiflexor joint moments. Joint moments are measures of the physical demands of the yoga poses. They are generated by muscular contractions and ligamentous constraints in response to the external moments generated by ground reaction forces. We believe that the high number of plantar-flexor poses we identified in the YESS series resulted in the large training effect identified in the present report.

Our nonsignificant hip abduction-strength changes may also be explained by our previously reported biomechanical findings, the poses that generated significant hip abduction torques, (e.g., single-limb poses like the unsupported Tree pose) were not added until late in the 32-week program [4–6]. Similarly, few of the poses required significant elbow flexor/extensor demands; thus, the nonsignificant changes in these strength measures are also not surprising. The lack of a significant change in knee-extension strength, however, was not expected, given the fact that several of the poses (e.g., Chair, Warrior II, and Crescent) generated relatively high knee extensor demands. These pose demands, however, were not greater than those produced during self-selected walking [5]. Thus, the lack of gains in knee extensor strength may be attributable to an insufficient amount of stimulation (training) provided by the postures in the YESS program.

4.3. Balance. Neither standing balance nor horizontal reach performance changed following the yoga intervention. Here again, biomechanical analyses can be used to help us understand these results. Many of the *Series I* poses were modified by allowing subjects to use a wall or chair to assist their balance. When the *Series II* poses were introduced (after week 16) the participants gradually reduced their dependence on the wall and chair, until they could stand on one limb (Tree) or hold a pose without wall support (Side Stretch). Consequently, these more balance-challenging pose versions were used for less than 16 weeks. Likely additional yoga practice beyond 32 weeks and/or the use of more balance-challenging *Series II* poses will be needed to effect changes in these static balance measures.

4.4. Limitations and Strengths of the Study. This was not a randomized, controlled trial (RCT); thus we are unable to compare the changes in each of the physical domains to those of an untreated control group. Rather, the study was Phase I, *intervention-development study* which was designed

to use biomechanical analyses of the yoga poses, and 16- and 32-week functional performance outcomes from the participants, in order to optimize the design of a future senior yoga program for testing in an RCT. Despite its limited Phase I design, statistically and clinically significant improvements (with large effect sizes) were identified across several important functional tests. The study also was not powered to tease out the effects of sex, diet, body composition, or pose performance skill on these functional performance outcomes; thus, future studies with large samples will be necessary to examine these potential covarying effects.

4.5. Summary. This is the first yoga study reporting the physical function adaptations in seniors, when detailed biomechanical profiles of the training poses have been reported. As such, the YESS study and its associated reports are important first steps in unraveling the complicated associations between exercise prescription and physical adaptation in senior yoga science. Our findings suggest that significant improvements in physical function and muscle-specific LE strength occur with the regular practice of a modified Hatha yoga program designed for seniors. Moreover, these adaptations correspond with the biomechanical demands (joint moments and muscle recruitment patterns) of the modified poses. This information can be used to refine the current program by providing a more balanced set of poses, for example, including more dorsiflexor, hip abductor, and single-limb-balance postures, and reducing the number plantar-flexor poses. Future studies, using a RCT design, will be necessary to determine if these biomechanics-based program changes improve outcomes while minimizing adverse events.

Competing Interests

The authors declare that they have no competing interests.

Acknowledgments

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Research Article

Yoga for Risk Reduction of Metabolic Syndrome: Patient-Reported Outcomes from a Randomized Controlled Pilot Study

Stephanie J. Sohl,[1,2] Kenneth A. Wallston,[3] Keiana Watkins,[1] and Gurjeet S. Birdee[1]

[1] *Vanderbilt University School of Medicine, Nashville, TN, USA*
[2] *Wake Forest School of Medicine, Winston-Salem, NC, USA*
[3] *Vanderbilt University School of Nursing, Nashville, TN, USA*

Correspondence should be addressed to Gurjeet S. Birdee; gurjeet.birdee@vanderbilt.edu

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Lifestyle change is recommended as treatment for adults at risk for metabolic syndrome (MetS), although adoption of new behavioral patterns is limited. In addition, most existing lifestyle interventions do not address psychological stress or quality of life, both of which impact the burden of MetS. Yoga, a form of physical activity that incorporates psychological components (e.g., maintaining attention, relaxation), is a promising intervention for improving the burden of MetS. This randomized controlled trial assessed the feasibility and preliminary efficacy of a 12-week yoga program coupled with an evidence-based health education program (HED) compared to HED alone. A secondary, exploratory aim examined perceived stress, quality of life, and related psychological outcomes (mindfulness, perceived health competence, and mood). Sixty-seven adults at risk for MetS enrolled (mean age [SD]: 58 [10] years; 50% male; 79% non-Hispanic White). Preliminary results revealed significantly larger improvements in two quality of life domains (role-physical and general health perceptions) in the HED plus yoga group versus HED alone ($ps < 0.05$). This is the first study that implemented lifestyle education along with yoga to evaluate the potential unique effects of yoga on participants at risk for MetS. A larger clinical trial is warranted to further investigate these promising patient-reported outcomes.

1. Introduction

Thirty-four percent of US adults have metabolic syndrome (MetS) [1], defined by a cluster of risk factors including insulin resistance, hypertension, dyslipidemia, and obesity [2]. Health behaviors including reduced physical activity and unhealthy diets are primary causes of MetS [3]. Thus, change in such behaviors is recommended as treatment for adults at risk for metabolic syndrome (MetS) [3], yet adoption of new patterns including increasing physical activity and improving diet is limited and adherence is poor [4]. In addition, most existing interventions do not address psychological stress. Chronic psychological stress affects the severity of MetS [5, 6] and quality of life, which is lower in this population [7].

Yoga is an ancient form of physical activity that emphasizes psychological components and benefits. Key psychological components of yoga include maintaining attention and relaxation [8]. Other studies of yoga for MetS have demonstrated promising results for improving cardiometabolic health [9–11], although further, more methodologically rigorous studies are needed. In addition, few studies have investigated the influence of yoga on psychological stress and quality of life outcomes in people with MetS [11–13]. Results from these studies are equivocal compared with those comparing yoga to a wait-list control group finding that yoga improves energy levels, general health perceptions, the physical component of quality of life, and social functioning [11, 13]; however, in another study [12], yoga was found to be less useful

than stretching for improving perceived stress. Conclusions that can be drawn from existing studies are further restricted due to the preliminary nature of the methodology that could be improved with stronger comparison groups and more systematic descriptions of and justification for the yoga protocol.

In a prior publication [14] we established the feasibility of combining health education and yoga into a single intervention for people with MetS, including strong adherence to the research protocol (>80%), although the study was not adequately powered to show statistical differences between the health education plus yoga group and the health education alone group on the primary outcome variables of interest related to cardiometabolic risk reduction (i.e., weight, blood pressure, lipids, and insulin resistance). Patterns in the data that were not statistically significant showed that participants at higher cardiometabolic risk (measured by insulin resistance) may gain additional benefit from yoga than a health education program alone. This overall study design aimed to match the education content in both study groups to control for expectancy and behavioral education in order to isolate the specific effects of yoga. Careful consideration was also given to systematically developing and describing the rationale for the yoga intervention, which allows future researchers to judge the quality of this trial and build upon knowledge gained [15]. This prior publication, however, did not report on data on the secondary, patient-reported outcomes that were also obtained in the trial.

The objective of the current set of analyses, therefore, is to assess perceived stress, related psychological constructs (i.e., mood, perceived health competence, and mindfulness), and quality of life as secondary outcomes in a randomized controlled study that compared a yoga program combined with an evidence-based health education program (HED) to HED alone in people at risk for MetS [14]. We hypothesized that the yoga program combined with HED would result in greater reductions in stress and improvements in related psychological outcomes and quality of life than HED alone.

2. Methods

The research protocol was approved by the Vanderbilt Institutional Review Board (ClinicalTrials.gov Identifier: NCT02899910). Participants willing and eligible for the study gave written consent.

2.1. Participants. Adult, English speaking participants were recruited from the Vanderbilt Adult Primary Care Center from June 2013 to January 2014 in Nashville, Tennessee. We utilized an electronic recruitment tool, PARTICIPANT LOCATOR, which identified potential research participants based on Vanderbilt University Medical Center's electronic clinical records system. Once a "match" was made, research study personnel performed secondary screening through medical record review and phone interview. Participants were also recruited through posted flyers and direct referrals from primary care physicians. The study was described as a lifestyle education intervention to support weight reduction, reduce blood pressure, and improve cholesterol without mention of mind-body practices or yoga.

The inclusion/exclusion criteria were codified into the tool and potential eligible individuals were identified. Inclusion criteria included a standard definition of metabolic syndrome: elevated waist circumference (men greater than 102 cm; women greater than 88 cm), impaired fasting glucose (100–125 mg/dL), elevated blood pressure (systolic $\geq$ 130 and/or diastolic $\geq$ 85), or diagnosis of hypertension and dyslipidemia (triglycerides $\geq$ 150 and/or HDL $\leq$ 40 for men; 50 for women). We excluded participants who were on oral diabetic medication or insulin or lipid medication or had systolic blood pressure $\geq$ 160 and/or diastolic $\geq$ 100, unstable cardiac disease (e.g., angina), life threatening arrhythmia, lung disease requiring oxygen supplementation at rest or with ambulation, history of dementia or cognitive impairment, or uncontrolled psychiatric disorders, such as major depression or psychosis, or currently participating in a mind-body practice or program. Sample size was based on the ability to determine changes in insulin resistance and is described in the primary publication [14]. However, the trial was stopped ahead of achieving the recruitment goal due to financial constraints.

Randomization (1 : 1 ratio) occurred after baseline testing. Randomization was stratified based on age ($\geq$ or <50 years) and gender. Treatment assignments were generated by a permuted blocks method randomly varying block size to 2 and 4. The random allocation sequence was generated by a person independent of the study team (i.e., not involved with enrolling participants, implementing the interventions, or data collection). Assignments were sealed by this independent person in numbered, opaque envelopes. The research assistants who enrolled participants were the same as those who opened the envelopes and assigned participants to the interventions. Participants and care providers were blinded to assignment. Participants randomized to the yoga plus health education (HED) group received 30 to 45 minutes of weekly yoga instruction, followed by 30 to 45 minutes of HED. They also received written instructions for home yoga practice and lifestyle changes based on the content of the HED curriculum. Participants randomized to HED alone received a weekly standardized HED curriculum matched in attention and time to the yoga plus HED arm. They also received written instructions for lifestyle changes based on the content of the HED curriculum. Thus, both groups received essentially the same HED content known to be efficacious [16], while one group also received yoga; however, the time and attention between the two groups were matched by reducing the length of time allocated to HED in the yoga group.

2.2. Interventions

Health Education (HED) Alone. Participants randomized to HED alone received 12 weeks of Group Lifestyle Balance™ Program, which is a comprehensive lifestyle behavior change program adapted directly from the National Institutes of Health funded Diabetes Prevention Program [16]. The Group Lifestyle Balance has been successfully translated to different communities as an educational intervention for MetS [17–20]. We implemented content from 12-core sessions to be delivered serially every week for 12 weeks. The HED program guides participants on behavioral change including healthy

Table 1: Example weeks from the progressive yoga protocol.

Activity-*Sanskrit name*	Type	Position	Basic description
		Yoga weeks 1 and 2	
(1) *Tadasana*	Movement	Standing	Bilateral arm abduction
(2) *Virabhadrasana*	Movement	Standing	Forward lunge with anterior arm extension
(3) Modified *Urdhva mukha svanasana*	Movement	Standing	Forward hip flexion and extension while leaning on chair
(4) *Utkatasana*	Movement	Standing	Squat
(5) *Pranayama*	Breathing	Lying on back	Observe breath
(6) *Eka pada apanasana*	Movement	Lying on back	Flexion of hip, one leg at a time
(7) *Jathara paravritti*	Movement	Lying on back	With knees bent bring knees together towards the floor, alternating sides
(8) *Apanasana*	Movement	Lying on back	Flexion of hip, both legs at same time
(9) *Jala bhavana*	Meditation	Sitting	Water visualization
		Yoga weeks 11 and 12	
(1) *Tadasana*	Movement	Standing	Raise arms from sides overhead and come up onto toes
(2) Modified *urdhva mukha svanasana*	Movement	Standing	Back extension while leaning on chair
(3) *Utkatasana*	Movement	Standing	Squat
(4) *Pranayama*	Breathing	Lying on back	Extending exhale
(5) *Jathara paravritti*	Movement	Lying on back	With knees bent bring knees together towards the floor, alternating sides
(6) *Eka pada apanasana*	Movement	Lying on back	Flexion of hip, one leg at a time
(7) *Jathara paravritti*	Movement	Lying on back	Both legs together placed laterally
(8) *Urdhva prasrita padasana*	Movement	Lying on back	Raise arms overhead and extend both legs towards ceiling
(9) *Mahamudra*	Movement	Sitting in chair	With one leg bent, hip abducted, reach for foot with hands keeping back arched.
(10) *Cakravakasa*	Movement	Kneeling	From kneeling bent forward position, shift weight forward while making back slightly arched
(11) *Pranayama - sitali*	Breathing	Sitting	Extend exhale using tongue breath
(12) *Jala bhavana*	Meditation	Sitting	Water visualization

diets and physical activity. Participants were given instructions to monitor calorie and fat intake using fat- and calorie-counting provided in the Group Lifestyle Balance Program and weekly weights at intervention visits from the beginning of the intervention [16]. The HED program was delivered by a dietician and graduate level dietician students. The Group Lifestyle Program has been delivered by diabetes educators in other community-based studies [17]. Classes ranged from 60 to 75 minutes to match the time and attention given to the yoga plus HED group. Classes were offered on the medical campus at different times during the week (weekday evenings and weekend days) to provide participants with more flexibility to attend.

Yoga Plus Health Education. Participants randomized to yoga plus HED received a 12-week program designed specifically for patients at risk for MetS. The goals of the yoga were to provide low to moderate intensity exercise while increasing the capacity for cognitive attention and relaxation. As with the HED alone condition, classes were offered on the medical campus twice a week to provide participants with more flexibility to attend regularly. The total class time ranged from 60 to 75 minutes. Classes had two components: yoga and HED. The yoga program consists of postures, breathing, and meditation based on yoga from the Krishnamacharya tradition in which all movements are coordinated with breathing and attention. The 12-week program was composed of six serial practices to be introduced every two weeks (Table 1). Yoga teachers were trained to provide specific modifications based on participant ability to maintain the function of the yoga techniques. The yoga component of the class initially lasted 30 minutes gradually increasing to 45 minutes over the 12 weeks. The intervention was designed to provide gradual increase in physical intensity over 12 weeks. The yoga was designed to be taught in group classes followed by daily individual home practice through the guidance of written instructions and drawn pictures.

All yoga teachers were required to have completed basic yoga teacher training programs accredited by Yoga Alliance (https://www.yogaalliance.org/), a nationally recognized organization that standardizes yoga certification. In addition, the four study yoga teachers underwent advanced training, which included intensive workshops conducted by

an expert yoga therapist consisting of lectures on rationale, techniques, and administration of intervention.

The HED segment of the classes occurred immediately after the yoga segment for 30 to 45 minutes. The HED portion was derived from the Group Lifestyle Balance Program described above. Participants received the same content and material in a condensed fashion. The HED content was modified to encourage yoga as the primary physical activity during the study period. The same dieticians who delivered the HED to the comparison group and delivered the HED to the yoga group.

2.3. Measures. Data (i.e., sociodemographic, biometric, and patient-reported outcomes) were collected at the Vanderbilt Clinical/Translational Research Center by research assistants as additional outpatient visits at baseline and after intervention (i.e., 12 weeks; patient-reported outcomes). Research assistants who collected outcome data were not blinded to group assignment. All patient-reported outcomes assessed in this study were secondary outcome measures. Adverse events were also systematically tracked during the study period.

Sociodemographics. Information on age, race and ethnicity, sex, and education was reported by participants enrolled in the study.

Biometrics. The following clinical variables related to MetS were assessed: weight, body mass index, waist circumference, systolic and diastolic blood pressure, and insulin resistance as measured by the homeostasis model assessment (HOMA) derived from fasting glucose and insulin levels [21].

Patient-Reported Outcomes. Higher scores indicate higher levels of the construct. Perceived Stress was measured with the 10-item Perceived Stress Scale (PSS-10; [22]). The PSS-10 is a reliable (coefficient alpha = 0.78) and valid measure; mood disturbance was assessed with the 65-item Profile of Mood States (POMS; [23]), which has a previously demonstrated validity and a reported coefficient alpha ranging from 0.76 to 0.95; health competence was assessed with the 8-item Perceived Health Competence Scale (PHCS) designed to determine a person's self-efficacy for managing their health [24]. The PHCS has been shown to be reliable (coefficient alpha range = 0.82–0.90) and valid; mindfulness was measured using the total score of the five subscales from the 39-item Five-Facet Mindfulness Questionnaire (FFMQ), observe, describe, act aware, nonjudge, and nonreact, which have been shown to be reliable (alpha coefficients range from 0.75 to 0.91) and valid; quality of life was assessed with the MOS Short-Form 36 (SF-36) questionnaire, which contains 36 items measuring health across eight different domains [25–27]. Domains included in the current analyses were physical functioning; social functioning; role limitations due to physical problems (role-physical); role limitations due to emotional problems (role-emotional); mental health; energy/fatigue; and general health perceptions. For each domain, scores are coded, summed, and transformed to generate a score from 0 (worst possible health state) to 100 (best possible health state).

2.4. Analyses. Missing data on individual scale items were replaced by the mean of the other items (if ≥ 75% of the respective subscale or total scale items had been completed). The remaining missing data were minimal (e.g., 3% PSS baseline, 11% PSS follow-up). Baseline data were compared using a t-test for continuous variables and chi squared tests for categorical variables to assess randomization. We utilized analysis of covariance (ANCOVA) to compare follow-up scores by treatment group with baseline scores as covariates. The interaction of treatment group and baseline scores was evaluated prior to conducting the ANCOVAs to test the assumption of homogeneity [28]. Partial eta-squared (η_p^2) effect sizes were also reported (0.01: small effect; 0.06: medium effect; 0.14: large effect [29, 30]). As sensitivity analyses, we also assessed within group changes over time using paired t-tests. All analyses were performed using SPSS statistical software (version 22).

3. Results

Of the 67 adults at risk for MetS enrolled (mean age [SD]: 58 [10] years; 51% male; 78% non-Hispanic White), all 67 participants were randomized, 66 participants completed the baseline questionnaires, and 59 participants completed the 12-week questionnaires (Figure 1). There were no significant differences in baseline variables by group (Table 2). There were also no adverse events related to yoga practice among study participants reported for the duration of the study.

3.1. Between-Group Results. The ANCOVA analyses revealed significant between-group differences for SF-36 role-physical ($F[1, 55] = 4.68$, $p < 0.05$, mean difference = 16.14 [95% Confidence Interval: 1.19, 31.08]) and SF-36 general health perceptions ($F[1, 55] = 6.61$, $p < 0.05$, mean difference = 9.46 [95% Confidence Interval: 2.09, 16.83]; Table 3) with medium effect sizes. Figure 2 illustrates results for SF-36 general health perceptions (SF-36 role-physical data showed a similar pattern). As shown in Figure 2, those who were instructed in yoga in addition to receiving HED showed significantly larger improvements in these domains of quality of life than those who received HED alone. ANCOVA analyses are reported in Table 3 with a footnote indicating whether the interaction of the intervention and baseline value of the outcome was a significant predictor of the outcome because these variables (i.e., physical functioning, role-emotional, and social functioning subscales of the SF-36) did not meet the assumption of homogeneity. No other significant between-group differences were found, although small effect sizes were also evident for reductions in perceived stress, mood disturbance, and improvements in other quality of life domains (SF-36 mental health, physical functioning, role-emotional, social functioning, and SF-36 energy/fatigue).

3.2. Within Group Results. Paired t-tests revealed significant changes in the yoga plus HED group for perceived health competence, SF-36 physical functioning, SF-36 role-physical, SF-36 energy/fatigue, SF-36 general health, and SF-36 mental

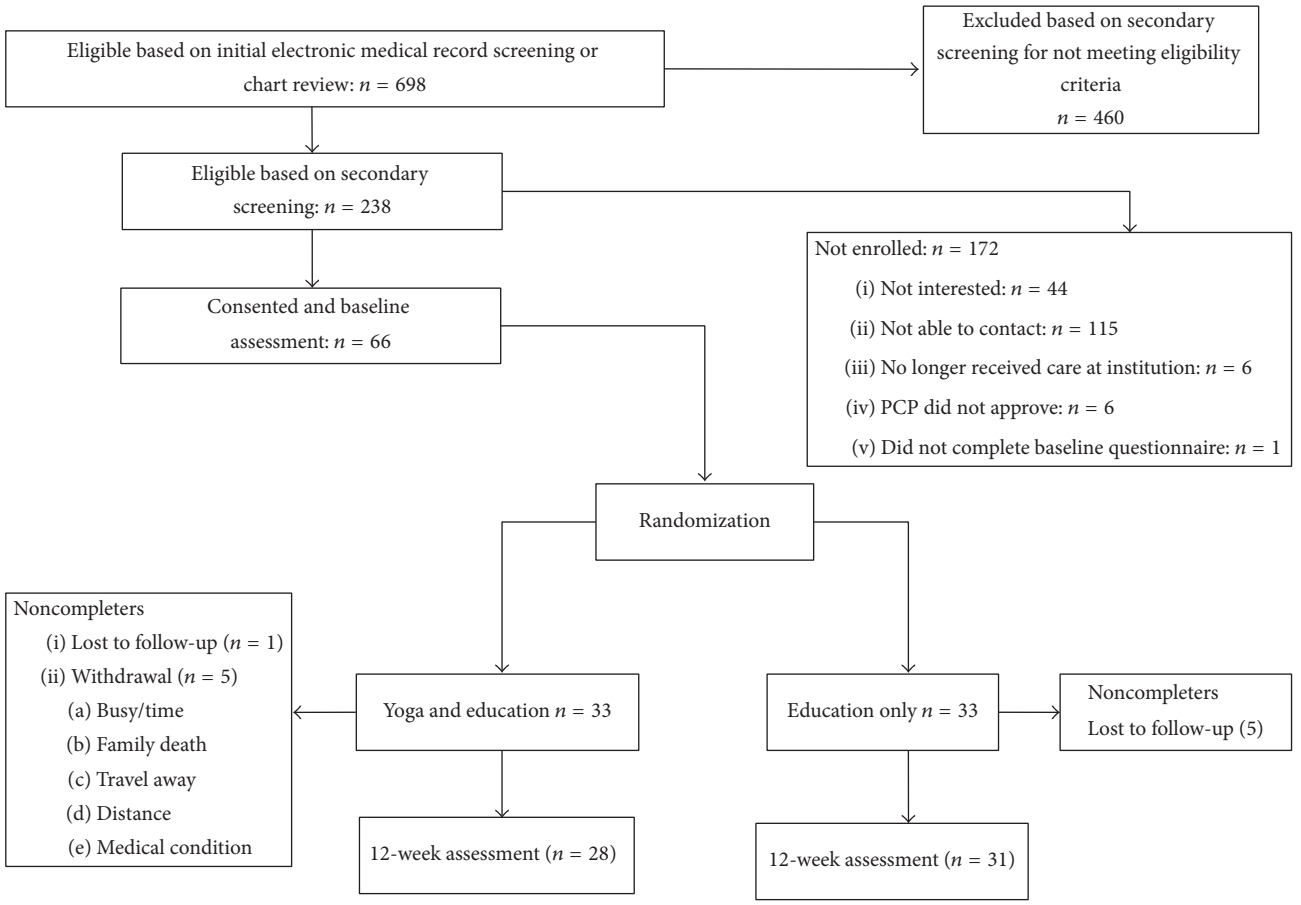

Figure 1: Study flow diagram. *Notes*. Fifty-nine participants completed the 12-week assessment for this study as compared to 56 reported in the initial study because some participants completed questionnaires, but not physiological testing.

health. Significant changes in the HED group were only found for health competence (Table 3).

4. Discussion

This is the first study among participants at risk for MetS that implemented an evidence-based lifestyle education intervention to conduct an exploratory evaluation of the potential unique additive effects of yoga, a mind-body practice, on psychological stress and other quality of life outcomes. Results revealed significant differences between groups in two quality of life domains, role-physical and general health perceptions. Small effects for differential group reductions in perceived stress, mood disturbance, and other quality of life improvements (mental health, physical functioning, role limitations due to emotional problems, social functioning, and energy/fatigue) were also noted. These preliminary results, along with promising indicators of feasibility reported in a prior publication [14], support pursuing further investigation of the potential efficacy of yoga for improving both physical and psychological outcomes of people at risk for MetS.

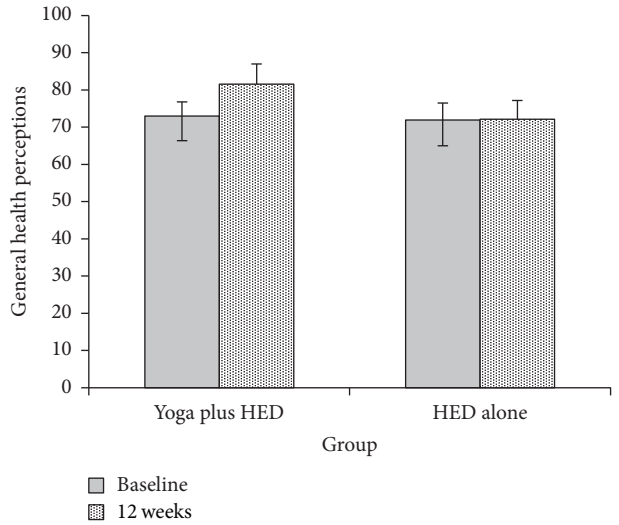

Figure 2: Between-group differences in changes in SF-36 general health perceptions from baseline to 12 weeks. *Notes*. HED: health education; SF-36: MOS Short-Form 36; adjusted means from the analysis of covariance are displayed at 12 weeks. Yoga plus HED $n = 27$, HED alone $n = 31$.

Table 2: Baseline characteristics of participants.

Participant characteristics[a]	Total sample ($n = 66$)	HED alone ($n = 33$)	Yoga + HED ($n = 33$)
Age (Mean [SD])	58.1 (10.0)	57.6 (10.5)	58.6 (9.7)
Race (n [%])			
Non-Hispanic White	52 (78.8)	26 (78.8)	26 (78.8)
Non-Hispanic Black	12 (18.2)	7 (21.2)	5 (15.2)
Hispanic	2 (3.0)	0	2 (6.0)
Sex (n [%])			
Male	33 (50.0)	16 (48.5)	17 (51.5)
Female	33 (50.0)	17 (51.5)	16 (48.5)
Education (n [%])			
High School or less	8 (12.1)	4 (12.1)	4 (12.1)
Some or 4-year college degree	32 (48.5)	19 (57.6)	13 (39.4)
More than a college degree	24 (36.4)	9 (27.3)	15 (45.5)
Biometrics (mean [SD])			
Weight (kg)	99.8 (16.5)	102.7 (17.2)	96.8 (15.5)
Body mass index (kg/m^2)	34.4 (5.7)	35.5 (6.0)	33.2 (5.2)
Waist	110.6 (12.2)	112.7 (12.8)	108.5 (11.3)
Blood pressure systolic (mm/Hg)	129.2 (13.1)	129.8 (11.7)	128.7 (14.6)
Blood pressure diastolic (mm/Hg)	76.9 (9.8)	77.4 (9.2)	76.4 (10.4)
HOMA-insulin resistance	2.0 (1.0)	2.1 (1.1)	1.9 (0.9)
Patient-reported constructs (mean [SD])			
Perceived stress (PSS)	12.6 (7.0)	12.1 (6.5)	13.2 (7.6)
Mood disturbance (POMS)	23.2 (15.7)	21.2 (15.0)	25.3 (16.3)
Health competence (PHCS)	27.3 (4.5)	27.3 (4.4)	27.3 (4.7)
Mindfulness (FFMQ)	144.1 (20.2)	144.9 (16.7)	143.2 (23.5)
Physical functioning (SF-36)	78.5 (18.8)	77.2 (22.4)	79.8 (14.4)
Role-physical (SF-36)	80.4 (33.8)	83.3 (30.4)	77.3 (37.2)
Role-emotional (SF-36)	81.5 (34.8)	84.9 (31.3)	78.1 (38.4)
Social functioning (SF-36)	88.7 (19.4)	87.9 (21.1)	89.5 (17.7)
Mental health (SF-36)	70.8 (12.4)	72.0 (10.3)	69.5 (14.1)
Energy/fatigue (SF-36)	57.1 (14.7)	60.0 (15.1)	54.1 (13.8)
General health perceptions (SF-36)	71.1 (15.2)	70.8 (16.1)	71.6 (14.4)

Note. HED: Health education; PSS: Perceived Stress Scale; POMS: Profile of Mood States; PHCS: Perceived Health Competence Scale (PHCS); FFMQ: Five-Facet Mindfulness Questionnaire; SF-36: MOS Short-Form 36. Percentages that do not add up to 100 are due to missing data.
[a]There were no significant differences by group as determined by t-tests and chi-squared tests.

Although an investigation of between-group differences was considered the most important, we also reported within group tests to inform future research. These latter results further supported that adding yoga to the educational intervention provided additional psychological benefits to patients above those due to health education. In particular, within group changes were significant in the yoga plus HED group for perceived health competence, physical functioning, role limitations due to physical functioning, energy/fatigue, general health, and mental health. Thus, for some of the between-group results that showed small effects (i.e., for mental health, physical functioning, and energy/fatigue), changes were likely due to improvements in the yoga plus HED group that were not seen in the HED alone group. A larger study may clarify whether group differences are large enough to warrant the inclusion of yoga in addition to HED or if yoga and HED may be considered as independent options for improving MetS.

Thus, this study contributes to other preliminary data supporting the fact that yoga improves quality of life outcomes in people at risk for MetS [11, 13]. More specifically, the positive effect of yoga on general health perceptions found in this study is consistent with that reported in a study of yoga as compared to a wait-list control [13]. Similarly, the small effects detected in our study for improvements in energy levels [11], the physical aspect of quality of life, and social functioning are also consistent with prior research [13]. The improvement in perceived stress shown in our data is consistent with that found when evaluating yoga as compared to a wait-list control group [11] and yet different than the finding in another study that stretching was more beneficial than restorative yoga for reducing perceived stress [12] that was

Table 3: Differences between and within groups over time.

Participant characteristics	HED alone baseline Mean (SD)	HED alone after Mean (SD)	Within group t	Yoga + HED baseline Mean (SD)	Yoga + HED after Mean (SD)	Within group t	Between groups difference (SD)[b]	Between groups F	Effect size (η_p^2)
Perceived Stress (PSS)	11.7 (6.5)	12.9 (9.4)	−0.70	12.9 (7.7)	10.7 (7.5)	1.57	−3.3 (2.2)	1.83	0.032
Mood disturbance (POMS)	19.4 (12.6)	21.8 (15.9)	−0.90	24.8 (17.1)	19.7 (17.1)	1.41	−7.5 (4.5)	1.26	0.025
Health competence (PHCS)	27.5 (4.4)	29.9 (5.3)	−2.19*	27.3 (4.7)	30.7 (5.2)	−3.08**	1.1 (1.6)	0.48	0.009
Mindfulness (FFMQ)	146.4 (16.2)	146.2 (18.8)	0.04	143.1 (22.6)	146.9 (22.7)	−1.37	5.8 (4.8)	0.42	0.008
Physical functioning (SF-36)	77.4 (23.1)	81.7 (19.2)	−1.21	78.3 (14.4)	89.2 (11.9)	−2.82**	6.6 (5.3)	3.32	0.057[a]
Role-physical (SF-36)	82.3 (31.1)	81.5 (37.6)	0.10	76.9 (36.6)	97.2 (8.0)	−2.79*	21.2 (11.1)	4.68*	0.078
Role-emotional (SF-36)	86.0 (30.8)	83.9 (33.2)	0.29	80.25 (38.4)	93.8 (20.7)	−1.89	15.7 (10.4)	2.26	0.039[a]
Social functioning (SF-36)	89.5 (19.7)	88.7 (18.4)	0.21	89.4 (19.2)	94.4 (17.5)	−1.27	5.9 (5.6)	0.20	0.030[a]
Mental health (SF-36)	72.8 (10.1)	71.6 (12.1)	0.19	70.3 (14.8)	72.6 (14.8)	−2.31*	3.5 (3.0)	0.89	0.016
Energy/fatigue (SF-36)	60.0 (15.4)	61.5 (15.4)	−0.50	54.4 (14.5)	64.8 (14.6)	−3.26**	8.9 (4.3)	2.27	0.040
General health perceptions (SF-36)	71.94 (15.8)	71.94 (17.8)	0.00	73.0 (13.2)	81.9 (11.8)	−3.59**	8.9 (4.2)	6.61*	0.107

Note. HED: health education. Mean values shown for participants with complete data at both time points (Yoga + HED n's = 27-28; HED n's = 30-31); PSS: Perceived Stress Scale; POMS: Profile of Mood States; PHCS: Perceived Health Competence Scale (PHCS); FFMQ: Five-Facet Mindfulness Questionnaire; SF-36: MOS Short-Form 36.

[a]Interpret with consideration of significant homogeneity of regression test results.

[b]Estimated standard deviation of the sample mean.

*$p < 0.05$; **$p < 0.01$.

attributed to higher levels of social support in the stretching group. Thus, results remain equivocal for the impact of a yoga intervention on perceived stress in this population, which is why evaluation of the impact of nonspecific therapeutic factors is important to consider in future studies [31]. In addition, the intensity of movement included in the yoga interventions differed in these studies, such that the current study included moderate intensity movements coordinated with breathing as compared to the other study of restorative yoga [12] that involved holding poses for extended periods of time. Thus, the optimal level of yoga movement intensity needed to improve perceived stress in people at risk for MetS is yet another area for further exploration.

These results on patient-reported outcomes taken together with results of other prior studies indicating that yoga likely improves cardiometabolic health [9, 10, 14, 32] suggest that yoga is a promising intervention for reducing the overall disease burden of MetS. Next steps for future research include conducting a larger, adequately powered randomized controlled trial to determine if these preliminary results persist. It would also further the research in this area to examine the comparative effectiveness of implementing a controlled aerobic exercise intervention as compared to yoga for improving MetS.

Limitations to consider when interpreting these findings include that this was an analysis of the secondary aims of a study, which had the primary aims of establishing the feasibility of combining yoga with health education and examining the cardiometabolic effects of that combination compared to health education alone. Thus, the psychological results reported in this article are intended to inform future work and are not to be taken as conclusive. In addition, while this study measured the psychological effects of these interventions, the study population did not have poor psychological health at baseline. Effects may be more pronounced in a select population with MetS and comorbid psychological conditions. Finally, results may not be generalizable since we did not evaluate if those who choose to participate in the study systematically differed from those who did not. Yet, these limitations are balanced by the strengths of the study design, including an active control group and a thoughtfully developed and described intervention.

5. Conclusions

In summary, results of this exploratory study suggest that yoga combined with health education may lead to improvements in quality of life outcomes among adults at risk for MetS over conventional standardized group health education. Although not statistically significant, small effect sizes were also evident for reductions in perceived stress and mood disturbance in the group that practiced yoga. These results are important because psychological stress and quality of life impact the overall MetS disease burden [5–7]. This study contributes to advancing yoga research for MetS by including an active control group and a systematically developed yoga intervention, as well as providing data to inform future research. An adequately powered clinical trial is warranted to further investigate the efficacy of yoga as compared to conventional standardized programs among adults at high risk for cardiometabolic disease.

Disclosure

The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

Competing Interests

The authors declare that they have no competing interests.

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Research Article

A Different Weight Loss Experience: A Qualitative Study Exploring the Behavioral, Physical, and Psychosocial Changes Associated with Yoga That Promote Weight Loss

A. Ross, A. Brooks, K. Touchton-Leonard, and G. Wallen

Department of Nursing Research and Translational Science, National Institutes of Health Clinical Center, Bethesda, MD 20892, USA

Correspondence should be addressed to A. Ross; alyson.ross@nih.gov

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Yoga interventions improve obesity-related outcomes including body mass index (BMI), body weight, body fat, and waist circumference, yet it is unclear whether these improvements are due to increased physical activity, increased lean muscle mass, and/or changes in eating behaviors. The purpose of this study is to expand our understanding of the experience of losing weight through yoga. *Methods.* Semistructured interviews were qualitatively analyzed using a descriptive phenomenological approach. *Results.* Two distinct groups who had lost weight through yoga responded: those who were overweight and had repeatedly struggled in their attempts to lose weight (55%, $n = 11$) and those who were of normal weight and had lost weight unintentionally (45%, $n = 9$). Five themes emerged that differed slightly by group: shift toward healthy eating, impact of the yoga community/yoga culture, physical changes, psychological changes, and the belief that the yoga weight loss experience was different than past weight loss experiences. *Conclusions.* These findings imply that yoga could offer diverse behavioral, physical, and psychosocial effects that may make it a useful tool for weight loss. Role modeling and social support provided by the yoga community may contribute to weight loss, particularly for individuals struggling to lose weight.

1. Introduction

Obesity, defined by the Centers for Disease Control and Prevention (CDC) as a body mass index (BMI) of 30 or greater [1], is epidemic in the USA and plays a pivotal role in many chronic health conditions [2, 3]. Greater than 30% of the US population (an estimated 72.5 million) is obese, at an annual cost of $147 billion dollars in medical costs [4]. A number of elements contribute to the obesity epidemic, but the Surgeon General has cited three main factors that play an important role: decreased physical activity; increased consumption of high caloric, high fat and nutrient-poor foods; and stress [5]. Strong evidence shows that a dose-response relationship exists between stress and abdominal adiposity and obesity [6]. Stress also affects food-seeking behaviors including increased consumption of foods high in fat and sugar [7, 8].

No single solution for reducing obesity exists. Over 300,000 bariatric surgeries were performed worldwide to treat obesity in 2011 and while potentially effective in reducing body weight and prolonging survival, these surgeries pose significant risk for complications [9]. Traditional weight loss programs focusing on diet and exercise to produce an energy deficit frequently result in weight loss, but long-term weight maintenance remains elusive [10]. Few of these treatments address the complex psychological and behavioral issues that initially led to weight gain.

Yoga, an ancient discipline involving physical poses, breath work, and mindfulness techniques, is the most commonly used nondietary or supplement complementary and alternative therapy for weight loss [11]. In clinical trials, yoga has improved a number of obesity-related outcomes including BMI, body weight, body fat, and waist circumference [12]. Individuals who practice yoga report that yoga helps to improve diet and body weight [13], and studies involving long-term yoga practitioners have found an inverse relationship between frequency of yoga practice and levels of obesity [14]. In the population-based, longitudinal vitamin

and lifestyle (VITAL) study of 15,550 adults, individuals who practiced yoga for at least four years were two to four times less likely to gain weight as they aged than individuals who did not practice yoga [15]. In a review of 55 research studies examining yoga for weight-related outcomes, Rioux and Ritenbaugh (2013) found yoga interventions to be effective for achieving weight loss and improving body composition [12]; the most effective programs were residential and longer in duration, required more frequent and home practice, included a yogic diet, and incorporated a variety of yoga practices as opposed to exclusively focusing on a single practice such as the physical poses or breath work.

The mechanism underlying yoga's effectiveness at improving weight-related outcomes remains unclear, although a number of pathways have been proposed including increased energy expenditure, reduced pain, enhanced mindfulness and body awareness, and reduced stress [16]. Yoga appears to downregulate the Hypothalamic-Pituitary-Adrenal (HPA) axis and the Sympathetic-Adrenal-Medullary (SAM) response to stress [17]. Additionally, yoga interventions have been shown to reduce binge eating and preoccupation with food [18, 19]. Adipose tissue acts as an endocrine organ, secreting adipokines that impact energy intake, fat storage, and metabolism such as adiponectin, which is anti-inflammatory, enhances insulin sensitivity, and is inversely associated with obesity, as well as leptin, which is highly correlated with obesity, insulin resistance, and type 2 diabetes [20]. In a cross-sectional comparison study involving 25 novice female yoga practitioners and 25 expert practitioners matched for age, fitness level, and abdominal adiposity, levels of leptin were 36% higher, and levels of adiponectin were 28% lower, in the novice group than in the expert group [21], suggesting that long-term yoga practice may affect metabolism. While yoga interventions may promote weight loss and improve body composition, nearly all of the research has been quantitative in nature, primarily examining whether a given yoga intervention results in weight loss. Of these, many utilize small sample sizes and weak methodology [16]. In those studies that have resulted in weight loss, it is unclear whether weight loss is due to increased physical activity, increased muscle mass, psychosocial factors, and/or changes in eating behaviors. The primary aim of this study is to expand our understanding of the experience of losing weight through the practice of yoga. The primary research question is as follows: "what is the experience of individuals who have lost weight and believe that yoga practice contributed to this weight loss?"

2. Methods

2.1. Participants, Recruitment, Ethics, and Consent. After receiving approval from the National Institutes of Health Clinical Center's (NIHCC) Office of Human Subjects Research Protection (OHSRP), investigators worked with the Iyengar Yoga National Association of the United States (IYNAUS) to locate yoga studio owners who might know individuals who had lost weight through the practice of yoga. Iyengar yoga was chosen because it has a highly structured national organization. In addition, unlike some schools of yoga that focus exclusively on one aspect of yoga such as the physical postures or breath work, Iyengar yoga is a classical form of yoga with strict standardization of teaching that emphasizes a number of aspects of yoga including the physical poses, breath work, and philosophy. Studio owners were emailed a letter providing information about the study and seeking help identifying individuals who had lost weight and believed that their yoga practice had contributed to their weight loss. The studio owners posted information about the study in their studios and/or in their newsletters, along with contact information for the investigators. Individuals who contacted the researchers and expressed interest in participating in the study underwent a telephone screen to assess for the eligibility criteria. Individuals were included if they were (1) 18 years or older and (2) a yoga practitioner who identified himself or herself as having lost weight through the practice of yoga. As per the approved protocol, verbal consent was obtained prior to each interview. Based upon a review of the literature regarding phenomenological approaches, a sample size of 20 was sought [22–24].

2.2. Data Collection. If the individual met the inclusion criteria, two semistructured telephone interviews were scheduled. In the initial interview participants were encouraged to explain their experiences with losing weight through the practice of yoga in as much detail as possible. All interviews were audiotaped and then downloaded onto a secure computer and transcribed verbatim. Within two weeks of the initial interview, the primary investigator read and reread the interview, extracting significant statements that captured the essence of the interview. Then, a short follow-up telephone call was made to confirm the findings of the interview and to offer participants an opportunity to add any additional experiences they did not think of during the first interview or to retract comments that they felt did not represent their views. These changes were incorporated into the subject's data. Having participants confirm a synopsis of the transcript and allowing subjects to add or retract comments in the follow-up interview allowed the researchers to better describe the experience and added rigor to the study [25].

2.3. Data Analysis. Qualitative data were analyzed using a descriptive phenomenological approach, as outlined by Colaizzi [26, 27]. Audio files were transcribed verbatim, and then a research team member performed an internal reliability check by listening to all audio files to confirm the interviews were correctly transcribed. Two investigators independently read and reread the transcripts to obtain a feel for the participants' experiences. They then extracted statements that described the phenomenon and illuminated the experience. They formulated meanings from these statements and assigned those meanings codes, words, or phrases that describe and summarize the meaning of the subject's experience. These codes were placed into themes, represented by categories of experiences that were universal to the participants that then were unified into a comprehensive description of the phenomenon. To assist in bracketing, not allowing prior experiences and beliefs to interfere with

data analysis, one coder was included who had no prior connections to yoga. During the iterative coding process, resolution of discordant meanings and minor reorganization of the thematic structure occurred through consensus.

To ensure trustworthiness of the data, three criteria for assessing rigor were considered: credibility, auditability, and fittingness of data [28]. Credibility was established by having two team members analyze the data independently and then having a third study team member with expertise in qualitative methodology validate the themes and coding. For auditability, examples of data are presented alongside each theme and subtheme to illustrate how data led to each theme being identified [25]. To address fittingness, 80% of participants were interviewed at two time points, providing a wealth of data from which to draw inferences and describe the experience [25]. NVivo (QSR International Pty Ltd. Version 10.0, 2012) was used for qualitative data analysis and management and to establish two measures of interrater reliability, a kappa coefficient and percent agreement. A kappa coefficient of 0.85 and percent agreement of 99.2% were calculated for this study. Descriptive statistics were calculated using IBM SPSS (Statistics for Windows, Version 22.0).

3. Results

Twenty-one subjects were screened, and 20 subjects participated in the semistructured interviews and are included in these analyses (Table 1). Sixteen participants (80%) were available to participate in a second interview. The initial interviews ranged between 9.3 and 45.1 minutes (m = 26.6 ± 9.5 minutes), and follow-up interviews ranged from 4.3 to 25.6 minutes (m = 12.6 ± 5.6 minutes). Mean age of participants was 56.6 (±9.4) years. Approximately three-quarters of the subjects were female (75%) and married (n = 14, 70%). Nearly all were white and non-Hispanic (95%). They were highly educated, with nearly three-quarters having a M.S. (30%) or Ph.D. (40%) degree. The majority (85%) of participants practiced Iyengar yoga, either exclusively (75%) or in combination with another style of yoga (10%). Subjects had practiced yoga between one and 45 years (mean = 15.3 ± 13.6) years. They reported an average weight loss of just over 26 pounds (range = 4–70). Prior to losing weight, just over half of subjects were overweight or obese (55%; n = 11), with a mean BMI of 27.4 ± 5.7 (range = 17.1–41.8). Current BMIs ranged from 16.4 to 31.5, with a mean of 23.2 (±3.2), placing the majority (75%) of subjects into the normal range for BMI.

Two distinct groups of individuals responded to the recruitment emails and participated in the study: those who were overweight when they started yoga (55%, n = 11), many of whom had repeatedly tried and failed to lose weight, and those who were of normal weight (plus one below normal), nearly all of whom had lost weight unintentionally (45%, n = 9). Several key themes emerged from the interviews including a shift toward healthy eating, the impact of the yoga community and yoga culture, physical changes associated with yoga, psychological changes associated with yoga, and the belief that the yoga weight loss experience was different than past weight loss experiences. While some of the themes and subthemes were universal, some differed slightly based upon the group to which individuals belonged (Table 2). The themes and subthemes, as well as the group differences, are discussed in the sections below.

Table 1: Participant characteristics (n = 20).

Characteristic	Frequency (%)	
Current age, mean (SD) range	56.6 (9.4) 35–67	
Gender		
Female	15 (75)	
Race/ethnicity		
White/non-Hispanic	19 (95)	
Marital status		
Married/partnered	15 (75)	
Single/divorced	4 (20)	
Widowed	1 (5)	
Education		
High school/some college	2 (10)	
College degree (undergraduate)	4 (20)	
Graduate degree (M.A., J.D., M.D., or Ph.D.)	14 (70)	
Work status		
Full time	12 (60)	
Part time	3 (15)	
Retired/not employed	5 (25)	
Years of yoga practice, mean (SD) range	15.3 (13.6) 1–45	
Style of yoga practiced		
Iyengar	15 (75)	
Iyengar + other	2 (10)	
Other*	3 (15)	
Weight loss in pounds, mean (SD) range**	26.3 (20.2) 4–70	
Current BMI, mean (SD) range	27.4 (5.7) 17.1–41.8	
BMI category	Before yoga	After yoga
Underweight (<18.5)	1 (5)	1 (5)
Normal (18.5–24.99)	8 (40)	15 (75)
Overweight (25–29.9)	5 (25)	4 (20)
Obese (≥30)	6 (30)	1 (5)

*Other styles included Ashtanga, Bikram, and Yin yoga.
**Weight loss was reported retrospectively and is therefore approximate.

3.1. Theme One: Shift toward Healthy Eating. Ninety percent of subjects (n = 18) reported a shift toward healthy eating that could be categorized into three distinct subthemes: an increase in mindful eating, changes in food choices, and decreased emotional and/or stress eating. Fifteen of the 20 subjects discussed the belief that yoga practice led to

Table 2: Frequency of interview content coded to themes and subthemes by preyoga body mass index (BMI).

Themes and subthemes	Preyoga BMI category	
	Normal weight ($n = 9$)*	Overweight ($n = 11$)
	Frequency (%)	
Shift toward healthy eating	7 (77.8)	11 (100)
Mindful eating	6 (66.7)	9 (81.8)
Changes in food choices	6 (66.7)	9 (81.8)
Decreased emotional or stress eating	2 (22.2)	7 (63.6)
Yoga community and culture	4 (44.4)	8 (72.7)
Role modeling healthy behaviors	2 (22.2)	4 (36.4)
Different than gym culture	4 (44.4)	6 (54.5)
Physical changes	9 (100)	11 (100)
Increased muscle tone	4 (44.4)	8 (72.7)
Change in metabolism	5 (55.6)	5 (45.5)
Effects of poses and practice on weight	9 (100)	9 (81.8)
Other physical effects contributing to weight loss	7 (77.8)	11 (100)
Psychological changes	8 (88.9)	11 (100)
Shift in mindset (health not weight)	2 (22.2)	5 (45.5)
Spirituality	5 (55.6)	4 (36.4)
Mindfulness and focus	5 (55.6)	10 (90.9)
Improved mood and emotional stability	4 (44.4)	10 (90.9)
Reduced stress	6 (66.7)	8 (72.7)
Self-esteem and self-acceptance	2 (22.2)	7 (63.6)
Different weight loss experience	4 (44.4)	10 (90.9)

* includes one practitioner who was underweight, but whose themes and subthemes matched the normal weight participants.

an increased sense of mindfulness or awareness regarding what they ate and the circumstances surrounding their food consumption.

> *I wouldn't say I was really dieting. I was just being very conscious of changing the way I related to food. And part of changing the way that I related to food involved just paying attention to what I eat and when I eat, and you know, I think I began to think of eating more as dining and less as fueling up.* (60-year-old male, overweight before yoga)

Many subjects who previously struggled with their weight discussed how they no longer found themselves mindlessly eating or making unconscious food selections and purchases.

> *. . .You could eat a bag of potato chips and not be aware of it. . . People can sort of zone out and they don't even know how much they are eating. Yoga definitely helps make you more mindful.* (44-year-old, female, overweight before yoga)

> *I don't do drive-thru's [sic]. I can walk through the bakery in any grocery store. I have no triggers after yoga.* (60-year-old female, overweight before yoga)

In addition to being more aware of what and how they were eating, there was a practical aspect of yoga reported by subjects in both groups in that they became aware of the negative effect that eating too much food had on their yoga practice.

> *Overeating also affects my practice. It's very hard to overeat the night before and get up the next morning and do a yoga class, because you have the feeling of you're still digesting.* (61-year-old female, overweight before yoga)

In the past, some participants reported exercising in order to be able to eat a certain number of calories, while now they ate to improve their general health and yoga practice.

> *So now instead of eating food as this reward post-exercise, like exercising to eat, I concentrate more on making healthy food choices to, I guess, feed my body in the right way so that it will help my yoga practice. . .If I was just exercising. . .and you can see on the machine the number of calories you burn. . .I was like, 'oh great, 600 calories.' I could just eat whatever I want. There don't seem to be any other consequences [of overeating]. It's not going to make me bad in spin class next time I go.* (35-year-old female, overweight before yoga)

They became aware that their practice was impacted not only by the amount of food they ate, but also by the type of food eaten. Subjects reported becoming aware of the effect of certain foods on their bodies during their yoga practice, including sugar, dairy, meat, and alcohol.

> *I could feel how eating meat made me feel sluggish and hard to work in poses as opposed to when I wouldn't."*(64-year-old female, normal weight before yoga)

> *I found that if I had dairy the yoga was harder.* (44-year-old female, normal weight before yoga)

> *Now I noticed that like, if I have a class on Sunday morning and even if I have a few glasses of wine on Saturday night, I might have just a slight headache on Sunday morning, so I just don't bother. You know, it's not a big deal to me one way or the other, but it's worth having a good class to not do anything that's not very important to me that's gonna kind of impact class.* (62-year-old female, normal weight before yoga)

In addition to avoiding certain foods and alcohol because of their impact on their yoga practice, a number of practitioners reported developing actual aversions to certain foods and alcohol.

> *Well, I have noticed a big change in my food. I used to like to eat a lot of sweets and I've just lost the taste for that. And I used to get up in the morning and have a couple of strong lattes to get me going, and I've lost the need for that since I've started pranayama* [yogic breathing] *about a year ago. So yeah, my diet has changed. And alcohol, I've kind of had a loss of interest in having a cocktail or a glass of wine on a regular basis. In fact, it's almost like I have an aversion to alcohol at this point. I just don't like the feeling of it.* (61-year-old female, underweight before yoga)

Food cravings, in general, decreased in a number of practitioners.

> *Well, with all of these things* [alcohol, sugar and caffeine], *I no longer crave some. I think because I became more aware of the downside of them.* (61-year-old female, underweight before yoga)

While one underweight subject reported that yoga practice led to an increase in appetite, a quarter of the participants specifically mentioned that yoga decreased their appetite.

> *I find my appetite goes down. I haven't been eating as much, getting back into yoga.* (39-year-old female, overweight before yoga)

The belief that yoga reduces swings in blood sugar and therefore reduces sugar cravings and overeating was a common one.

> *It's interesting. I can go into a yoga class feeling kind of hungry. Maybe I go before breakfast or around breakfast time, and I come out of class, I am not really hungry, and I think it's just because for some reason, blood sugar evens out in yoga. I have definitely noticed that it moderates hunger, and then it sort of gives me time, because my blood sugar isn't just plummeting. . .You don't have these blood sugar swings that would drive me just to grab the first thing I see. . .If your blood sugar is dropping, you're not in a good mood, and you're not really in control as much.* (62-year-old male, overweight before yoga)

In addition to variations in blood sugar impacting their food choices, many of the initially overweight subjects discussed a direct relationship between their moods and stress levels with their food consumption.

> *Not only how many calories you put in but how much food you actually eat is really determined by your emotional state. So I . . .had a big habit of eating whenever I was stressed. . .I would eat to calm myself, and I would eat when I was bored. I'd eat when I was lonely. I'd eat when I was too excited. I ate for social reasons; I mean every reason in the book.* (61-year-old female, overweight before yoga)

Participants discussed how this pattern of eating due to stress or negative emotions lessened after starting to practice yoga.

> *My emotion eating. There was less that I needed. There was less emotion that I needed to feed.* (44-year-old female, normal weight before yoga)

While the yoga may not have eliminated unhealthy eating patterns, it helped to improve them.

> *That it did help me with recognizing, like, 'oh, you are an anxious eater.' And I still did that when I started practicing yoga. I did have an eating disorder and I still struggle with it a little, but not as badly because yoga helped me calm the anxiety so that food was not so numbing. I don't have to numb through food. I could use the yoga to calm.* (44-year-old female, overweight before yoga)

Not only did yoga reduce unconscious and emotional eating, but participants also believed that the stress reduction associated with yoga put them in a better frame of mind to make healthier food choices.

> *When I'm doing yoga, I'm not as anxious. Everything is a little slowed down. I can go in there [*the cafeteria*] and I can organize things better and think better, and I'll say, 'Ok. Well, they have fish and they've got rice, macaroni and cheese, and all this stuff, but they also have green beans, and I can eat those today. So I'm going to eat the fish, and I'm going to get green beans and drink some water. And I'll eat it, and I don't want anything more. And I can just kind of go back to work. While, if I'm not doing yoga and I'm just really stressed and very focused, and the whole day is rushing by, I might eat and then I'm still hungry. And I might eat some chocolate or something else, and I'll need*

> *that extra bit of sugar to sort of propel me through the rest of the day. I find that I don't eat that when I'm doing yoga.* (39-year-old female, overweight before yoga)

3.2. Theme Two: Impact of Yoga Community/Yoga Culture. A second theme that emerged from the interviews of sixty percent of participants ($n = 12$), particularly those who were initially overweight, was that the yoga community and yoga culture played a role in their weight loss. Two subthemes emerged, including that their yoga teachers and more advanced yoga practitioners served as role models for healthy behaviors and that there was a different attitude and sense of support among the yoga community than that which is found in the culture of many gyms or health clubs. Participants believed that both of these aspects of social support contributed to their weight loss.

Participants discussed being inspired to live a healthier lifestyle by their peers and, even more so, by their yoga teachers, who served as role models for healthy living. For some, the inspiration they received from their teachers was profound, and it influenced their food choices.

> *I was shocked, totally shocked, to see my teacher move. . .when I saw her move in the sun salutations and she did this headstand with lotus and these backbends that were just beautiful. I just couldn't believe my eyes. I don't think it was possible to, you know, have that kind of capability. . .I began to emulate my teacher, and I think that she inspired me to think twice about what I was eating.* (64-year-old female overweight before yoga)

A number of participants specifically discussed how just being in the presence of individuals in the yoga community and witnessing their behaviors influenced their own health behaviors and food choices.

> *Yoga, the practice itself and the people who teach it and do it, have a healthier world view and way of looking at life, and so you become the people you're around, and so it just helps.* (44-year-old female, normal weight before yoga)

Not only did the individuals within the yoga community serve as role models for healthy behaviors, but also they also were role models for taking care of oneself, which translated into making healthier food choices. The yoga community conveyed an attitude of kindness, acceptance, and support, and participants discussed how this attitude transferred to how they treated themselves.

> *Being in that culture, that society, of being around people who are like, 'be good to yourself', 'be kind to yourself', it changes your thinking as well so that. . . I'm not, 'oh I'm such a horrible person and I'm going to go eat some potato chips.* (44-year-old female, normal weight before yoga)

Participants perceived this attitude as being distinctly different than the attitude and mindset that participants had experienced at the gym.

> *. . .takes the competitive thinking out of the game and when you go to yoga, at least in the studio where I practice, it's a very safe place. . .You walk up the stairs and you close the door and go into your studio and you're not competing with everybody else. There's a gentleness in there and you can really just focus on yourself and practice leaving what else is going on in your life, leaving it somewhere else and just focusing on yourself, and that's really rewarding.* (59-year-old female, overweight before yoga)

Several participants commented that the safety and comfort they felt during yoga may be related to the fact that, unlike the gym, not everyone in a yoga class was thin and fit, allowing them to feel comfortable participating. A number expressed the belief that the type of yoga classes one attends would make a difference as to whether it would support one's efforts at weight loss.

> *You know, I don't see a lot of hard bodies. There's not what I would call a hard body in the yoga classes. They are not gym bunnies. They're normal people with a soft outer layer of fat. But they're healthy, you know, and they're all different sizes. I felt comfortable even when I was close to 200 pounds. . .. There were no model-looking like people, there were no midriffs showing, just a bunch of normal. . . now again, because I picked that kind of studio. I have seen studios that are a whole lot like the gym workout; it's like an aerobics class instead of a yoga class. Where the gym hosts you know, a yoga class, amongst all their other aerobic lineups, that's a different environment. For me, I don't think I would have had the experience or the success that I've had, had I just joined the gym and hit the weekly class at the gym.* (44-year-old female, normal weight before yoga)

3.3. Theme Three: Physical Changes. All 20 participants spoke of physical changes associated with yoga practice that they believed contributed to their weight loss. Several subthemes emerged including increased muscle tone, changes in metabolism; specific effects of yoga poses and yoga practice on weight; and other general physical changes that contributed to weight loss.

When asked how yoga helped them to lose weight, the most common answer from all practitioners was through the building and toning of muscle.

> *I think yoga helps to develop and tone muscle. My muscle mass is definitely higher now than it was before, so I think that obviously contributes to weight loss.* (61-year-old female, overweight before yoga)

A number believed that the increase in muscle mass caused an increase in metabolism.

> *On a basic level, it builds muscle, which burns more calories. So I think that, in itself, the way it tones muscles, just in my daily life, after I'm toning my muscles, then I can go out and I'm moving and burning more calories.* (44-year-old female, overweight before yoga)

In particular, practitioners of Ashtanga and Bikram styles as well as more vigorous forms of Iyengar yoga spoke of an aerobic effect that burned calories.

> Y*ou are using a lot of energy as you're moving through the poses, so it is a form of exercise, and sometimes aerobic exercise, because of certain kinds of sequencing of poses.* (61-year-old female, normal weight before yoga)

Among nearly all of practitioners whose BMI fell within the normal category (88%), as well as several who were initially overweight (27%), the weight loss was unintentional. Three of the normal weight practitioners were so alarmed by their weight loss that they consulted their physicians. A number of practitioners believed that performing specific poses contributed to their weight loss. Among those poses that were most commonly cited as contributing to weight loss were twisting poses as well as inverted poses such as head stand and shoulder stand. Almost half of participants ($n = 9$) mentioned losing weight from specific areas of their body, and eight of these nine subjects reported losing weight from their waist or midsection.

> *The weight loss was specific to my abdomen.* (59-year-old male, normal weight before yoga)

In addition to losing weight when they began to practice yoga, a number of subjects reported that their weight increased when their yoga practice was interrupted for a period of time, highlighting an inverse relationship between yoga practice and weight.

> *I stopped doing yoga for a few years and slowly gained more and more weight. And then last year I decided to start doing yoga again. I'd already lost about 20 pounds through diet alone, but I started to do yoga again and probably lost another five to ten pounds.* (39-year-old female, overweight before yoga)

Subjects reported a number of general physical improvements that coincided with yoga practice and contributed to their weight loss. Among these physical changes were improved sleep and decreased pain. In addition, nearly every subject (90%) talked about feeling better physically, with most mentioning feeling more energized, which in turn allowed them to be more active.

> *I feel more energetic. I can walk better. I can reach things better, so it helped with flexibility. I was better able to move my body and in general get through the day easier.* (44-year-old female, overweight before yoga)

3.4. Theme Four: Psychological Changes. Nearly all of the practitioners (95%) discussed psychological and mental changes associated with yoga practice. Particularly among the practitioners who were initially overweight, they believed these changes played a role in their weight loss. Within this theme, a number of subthemes emerged: a shift in mindset away from weight loss and towards health; spirituality; increased mindfulness and focus; improved mood and emotional stability; reduced stress; and increased self-esteem and self-acceptance. A number of subjects specifically reported a shift in mindset after starting yoga that contributed to their weight loss.

> *It was just as my mindset shifted, as I made health a priority and not weight a priority, my diet changed.* (44-year-old female, normal weight before yoga)

Several participants specifically emphasized that yoga was more than a physical practice, with nearly 50% of subjects mentioning spirituality and/or spiritual effects.

> *It's not just a physical practice. If you want to practice yoga, you are going to do more than the poses. That's the real practice. I mean, that's what it encompasses, the spiritual practice.* (63-year-old female, normal weight before yoga)

Among the psychological changes they noted were increased mindfulness, clarity, focus, and discipline.

> *I was thinking the main focus for me is that it's made me more body aware and made me more mind aware, so I have been able to make better choices.* (62-year-old male, overweight before yoga)

This newfound awareness extended to body awareness. This was a new experience for the initially overweight subjects, many of whom reported past problems with proprioception, the sense of where one's body and body parts are oriented in space.

> *The practice has really helped me become very aware of my body.* (61-year-old female, overweight before yoga)

The subjects also discussed improved mood, greater emotional stability, and less reactivity.

> *I walked out and I felt so balanced and mellow and just good from the very first session. So I would say I felt the emotional, the psychological side of the yoga experience immediately.* (60-year-old male, overweight before yoga)

Yoga also provided an outlet for dealing with stressful situations and people that contributed to weight loss, particularly for the subjects who were overweight.

> *I'm much more able to deal with my mother. . .It allows you to protect yourself. That's part of the*

> *eating thing too. You know with yoga you can protect yourself from forces, so instead of having a conversation with my mother that frustrates me and makes me angry which sends me to the mac and cheese, I don't do that anymore.* (59-year-old female, overweight before yoga)

Other psychological changes that bolstered weight loss, particularly for the initially overweight subjects, included increased self-esteem, self-confidence, and self-acceptance.

> *It's increased my confidence, but more than that, it's made me satisfied with what I am. So I'm not looking to be something other than who I am, and that was what kind of freed me up to say, 'OK. I can do this. I can lose this weight.* (59-year-old female, overweight before yoga)

This improved sense of self helped the participants who were initially overweight begin to take better care of themselves.

> *It made me satisfied with who I am, so I stopped doing bad things to myself, like eating really bad stuff…You stop punishing yourself. I think poor eating is a little bit of punishing yourself. You know, if you don't like who you are, then you don't really care if you're fat.* (59-year-old female, overweight before yoga)

Particularly for the subjects who were initially overweight, many of whom reported past problems with proprioception and body dysmorphia, the newfound body awareness and acceptance were profound.

> *I rarely have experiences of body dysmorphia, and I know this is a huge thing with many women…I haven't had this experience, and I think it's because I have this level of comfort in my body that I have never had before. I have this centeredness in my body that doesn't feel like a passing thing.* (60-year-old female, overweight before yoga)

It should be noted that two themes, "a shift toward healthy eating" and "psychological changes," would frequently overlap and were often double coded. Subjects would often begin discussing psychological changes associated with yoga and then make a conscious or unconscious transition into discussing an increase in mindful eating or a decrease in cravings or stress-related eating.

3.5. Theme Five: A Different Weight Loss Experience. Nine out of the eleven subjects who were overweight or obese when they started yoga practice discussed trying unsuccessfully to lose weight in the past. For these subjects, this weight loss experience was distinctly different than past weight loss experiences. For many, the primary difference was that this weight loss was often unintentional and, unlike in the past, not difficult.

> *It was the easiest experience for weight loss that I have ever had. This time it was just, I don't know, it was totally different for me.* (60-year-old female, overweight before yoga)

A number of the subjects reported that they struggled with adhering to formal weight loss plans in the past, and they believed yoga gave them the strength and put them in the proper mind set to adhere to their diet or formal weight loss program.

> *I was on a medically supported program of weight loss…but it was yoga that put me in the mindset that I could possibly even try to do this…No, I wouldn't have had the mental strength to do that in the past…* (59-year-old female, overweight before yoga)

Nearly all of the eleven subjects who were initially overweight reported a past pattern of losing weight through diet and/or exercise, only to regain it.

> *I was always a yo-yo dieter before. I was 40 pounds up, 40 pounds down. It was always the same 40 pounds.* (60-year-old female, overweight before yoga)

Unlike in the past,all of the subjects reported maintaining the weight lost through yoga practice, many for decades.

> *I have kept it off for quite some time. You know, I feel pretty stable now and that's the yoga.* (61-year-old female, overweight before yoga)

A quarter of subjects emphasized the difference between yoga and standard exercise, as it pertains to weight loss.

> *I have always hated going to the gym…all through my attempts to lose weight, I would go to the gym and go home and eat whatever I felt like. So it was always very self-defeating. It was a vicious cycle of, 'Oh, I'll go exercise, and I'll go eat.' So, that's gone. I get this very clear physical power when I finish a class and it is combined with a deep relaxation…I don't think you get that from the fitness industry. I mean, you get a routine.* (60-year-old female, overweight before yoga)

4. Discussion

The demographic characteristics of this sample of yoga practitioners are similar to those found in national surveys of yoga practitioners in the USA and abroad [13, 29], with the majority being white, educated females. The themes that arose in this study were similar to those found by McIver et al. (2009), who qualitatively analyzed journals of 20 obese women attending a 12-week yoga treatment program for binge eating and found that the yoga program led to a healthy reconnection to food, physical empowerment, and increased awareness [19]. The concept of mindfulness was pervasive in this study, as many subjects reported an increase in mindful

awareness regarding the food they ate, the emotions they felt, and the connection between the two. Mindfulness interventions may be effective additions to traditional weight loss programs, as a review of the literature on mindfulness and weight loss found that mindfulness interventions resulted in significant weight loss in 13 of the 19 studies reviewed [30]. Authors of this review suggested that mindfulness may play a role in weight loss by increasing one's self-regulatory capacity, increasing awareness of negative emotions and social cues that trigger overeating, and facilitating tolerance for discomfort [30]. The themes that emerged from the participants in this study, particularly those who were initially overweight, supported these conclusions.

Stress was a concept that was discussed repeatedly in this study, as many brought up the relationship between stress and binge eating and the role of yoga in relieving stress and stress-related eating. Evidence supports that stress and the resultant release of cortisol are associated with increased consumption of high fat, high-sugar foods [7, 8]. Yoga appears to decrease stress by downregulating the HPA axis response to stress. Perhaps this is the pathway through which yoga reduces stress-related eating. Because nearly half of the subjects reported losing weight specifically in their abdomen and there is a strong relationship between stress, cortisol release, and abdominal adiposity [6], the abdominal weight loss may also be an indication of decreased HPA axis activation.

A novel theme that emerged in this study was the influence of the yoga community and yoga culture on weight loss. Epidemiological data from the Framingham Heart Study showed that obesity appears to spread through social ties, with one's odds of becoming obese increasing if one's spouse, siblings, and most importantly one's friends became obese [31]. The authors suggested that one possible explanation for the contagious nature of obesity is the underlying norms regarding the acceptability of being overweight and/or consuming unhealthy foods. The authors concluded that social networks potentially could be used to spread positive health behaviors, a phenomenon that appears to have occurred in this study. Not only do social networks influence health behaviors, but social support also plays a critical role in weight maintenance [32]. Participants discussed the supportive, friendly environment of the yoga studios, and many of the initially overweight subjects believed that the social support and acceptance that they received were critical to their weight loss success. Likewise, a number emphasized that practicing yoga in studios or gyms that encouraged an atmosphere of competition or that attracted primarily thin, fit yoga practitioners would have been counterproductive to their weight loss attempts. There appear to be differences in yoga practitioners who take classes in gyms versus yoga studios, as Dittmann and Freedman (2009) found that yoga practitioners who take classes in gyms were primarily motivated to practice for physical and appearance reasons, while practitioners who took classes in yoga studios were primarily motivated for psychospiritual reasons [33].

While many commercial weight loss programs focus on an equation of calories in and calories out, weight gain likely is more complicated and includes physiological, social, environmental, and psychological factors such as stress, anxiety, and depression [34]. The participants viewed yoga as having a broad range of effects that contribute to weight loss. These effects would overlap, as a number of the themes frequently emerged simultaneously in the transcripts. For example, psychological changes such as increased mindfulness, improved mood, or reduced stress would often precede or be double coded with the theme of healthy eating, indicating that they were intertwined, at least in the thoughts and words of the participants.

There are a number of limitations of this study. As with any study using purposive sampling, the risk of selection bias could lead to a nonrepresentative sample. While the researchers conducting data analysis attempted to use bracketing to minimize their own bias, personal bias could affect coding. Another weakness of the study is the small sample size. While twenty subjects are not small for a qualitative study, only 10 participants from each of the groups were interviewed. Greater insight might be gained by interviewing more individuals in each of the two groups. However, this study has a number of strengths including the novelty of this underexplored topic, the rigor of the qualitative analysis and validation process, and the individual variation within the subjects that allowed unique experiences and subgroups to emerge.

Further research is needed to examine the physiological, psychological, and behavioral pathways whereby yoga leads to weight loss, including uncovering the mechanisms that explain how yoga decreases stress eating and reduces waist circumference. Research is needed to determine whether yoga can stand alone as a method of weight loss or should be used in combination with other weight loss interventions such as diet and exercise. The majority of the previously overweight subjects used a combination of diet and yoga to lose weight, while the weight loss of the subjects with normal BMI levels tended to be more unintentional and was not paired with conscious changes in diet. Further research is needed to ascertain the differential effects of yoga on both normal weight and obese populations, as this study suggests that the effects may differ. One area of research that has received little attention is the social aspect of yoga practice. While numerous randomized controlled trials have provided evidence of the physical and psychological health benefits of yoga in a variety of healthy and diseased populations [17], few have focused on or examined the influence of the social support provided in those interventions.

5. Conclusions

The findings of this study imply that yoga may offer diverse psychological, physical, and social effects that may make it a useful tool for healthy, sustained weight loss. The yoga practitioners reported less stress eating, reduced appetite, fewer cravings, and a shift toward healthier, more mindful eating. Yoga provided them with social support and healthy role models. The subjects believed that yoga led to physical and psychological changes that supported weight loss including increased muscle tone, improved metabolism, reduced stress, as well as increased awareness, improved mood, and greater self-acceptance and self-esteem. This weight loss experience

was markedly different than past attempts, in that the weight loss was easier, and subjects felt more confident in their ability to maintain lasting weight loss.

Competing Interests

The authors declare that they have no competing interests.

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Review Article

A Systematic Review and Meta-Analysis Estimating the Expected Dropout Rates in Randomized Controlled Trials on Yoga Interventions

Holger Cramer,[1,2] Heidemarie Haller,[1] Gustav Dobos,[1] and Romy Lauche[1,2]

[1]*Department of Internal and Integrative Medicine, Kliniken Essen-Mitte, Faculty of Medicine, University of Duisburg-Essen, Am Deimelsberg 34a, 45276 Essen, Germany*
[2]*Australian Research Centre in Complementary and Integrative Medicine (ARCCIM), University of Technology Sydney, 15 Broadway, Ultimo, Sydney, NSW 2007, Australia*

Correspondence should be addressed to Holger Cramer; h.cramer@kliniken-essen-mitte.de

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A reasonable estimation of expected dropout rates is vital for adequate sample size calculations in randomized controlled trials (RCTs). Underestimating expected dropouts rates increases the risk of false negative results while overestimating rates results in overly large sample sizes, raising both ethical and economic issues. To estimate expected dropout rates in RCTs on yoga interventions, MEDLINE/PubMed, Scopus, IndMED, and the Cochrane Library were searched through February 2014; a total of 168 RCTs were meta-analyzed. Overall dropout rate was 11.42% (95% confidence interval [CI] = 10.11%, 12.73%) in the yoga groups; rates were comparable in usual care and psychological control groups and were slightly higher in exercise control groups (rate = 14.53%; 95% CI = 11.56%, 17.50%; odds ratio = 0.82; 95% CI = 0.68, 0.98; $p = 0.03$). For RCTs with durations above 12 weeks, dropout rates in yoga groups increased to 15.23% (95% CI = 11.79%, 18.68%). The upper border of 95% CIs for dropout rates commonly was below 20% regardless of study origin, health condition, gender, age groups, and intervention characteristics; however, it exceeded 40% for studies on HIV patients or heterogeneous age groups. In conclusion, dropout rates can be expected to be less than 15 to 20% for most RCTs on yoga interventions. Yet dropout rates beyond 40% are possible depending on the participants' sociodemographic and health condition.

1. Introduction

Attrition, that is, the loss of participants during the course of a study, is a potential threat to internal and external validity in randomized controlled trials (RCTs) [1]; and the underestimation of the size of attrition may severely affect the confidence in the results of a study by increasing the risk in type II errors (false negative results) [2]. Overestimating dropout rates on the other hand will result in overly large sample sizes, raising both ethical and economic issues: unnecessary large numbers of participants might be exposed to a potentially ineffective or even dangerous intervention [3], not to mention the enhanced study expenses related to overly large sample sizes. Given limited available funds, this is probably an even more complex problem in complementary and integrative medicine than in conventional medicine [4]. Yoga not only is among the most commonly used [5] but also is one of the most commonly studied complementary and integrative therapies, with more than 50 randomized controlled trials being published each year now [6].

Study design and patients' baseline characteristics were the most common factors associated with attrition in clinical trials on exercise interventions. Relative to an active comparator, the use of waiting list designs may be detrimental to the attrition rate in the control group [7]. Furthermore, pretreatment physical fitness, depressive symptoms, and increased fatigue level seem to produce higher dropout rates [8, 9] as well as a lower educational level of the participants [10]. Factors specifically associated with attrition in yoga trials have not been identified yet; therefore, dropout rates for yoga

trials are mainly estimated based on personal experience or rules of thumb [11]. In order to provide reliable estimates for expected dropout rates in future yoga trials, this systematic review aimed to systematically assess and meta-analyze the reported dropout rates in previously published RCTs on yoga interventions and to analyze their associations with study characteristics.

2. Methods

This systematic review was based on a previously published bibliometric analysis that descriptively summarized characteristics of RCTs on yoga interventions [6]. The paper is in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [12], unless otherwise indicated.

2.1. Eligibility Criteria

2.1.1. Types of Studies. RCTs were eligible. No language restrictions were applied; if necessary, language experts were consulted.

2.1.2. Types of Participants. Studies on all types of participants were eligible. No restrictions were made regarding sociodemographic characteristics or health status.

2.1.3. Types of Interventions. Studies were eligible if they compared yoga interventions to one or more nonyoga interventions or untreated control groups. No restrictions were applied regarding the tradition, length, frequency, or duration of the studied yoga programs. The specific yoga techniques included in the intervention were not restricted as long as the intervention was based on yoga theory and/or traditional yoga practices. Studies allowing individual cointerventions were eligible while studies where yoga was part of a multimodal intervention were excluded.

2.1.4. Types of Outcomes. Studies were eligible if they at least reported the dropout rate for the yoga intervention group.

2.2. Literature Search Methods. The literature search comprised four electronic databases from their inception through February 12, 2014 (MEDLINE/PubMed, Scopus, IndMED, and the Cochrane Library) and was constructed around search terms for "yoga" and a filter for retrieving randomized controlled trials [6]. The complete search strategy is shown in Table 1. The reference lists of identified original articles or reviews and the tables of contents of the *Journal of Yoga & Physical Therapy* and the *International Scientific Yoga Journal SENSE* were searched manually for additional eligible studies. Abstracts identified during literature search were screened independently by two review authors; and potentially eligible articles were then read in full by two review authors to determine whether they actually met the eligibility criteria.

2.3. Data Extraction. Study and participant characteristics (country of origin, medical conditions, gender, and age groups), intervention characteristics (duration, specific yoga techniques used), and control group characteristics (type of control intervention) were extracted from the included studies independently by two authors using a standardized data extraction form. Dropout rates for the yoga groups and (if available) for the control groups were extracted independently by two authors.

Table 1: Search strategy.

	PubMed
#1	Yoga[MeSH Terms]
#2	Yoga* [Title/Abstract] OR Yogi* [Title/Abstract]
#3	#1 OR #2
#4	Randomized Controlled Trial[Publication Type]
#5	Random* [Title/Abstract]
#6	#4 OR #5
#7	#3 AND #6
	Scopus
#1	TITLE-ABS-KEY(yoga*) OR TITLE-ABS-KEY(yogi*)
#2	TITLE-ABS-KEY(random*)
#3	#1 AND #2
	Cochrane Library
#1	MeSH descriptor: [Yoga] explode all trees
#2	Yoga*:ti, ab, kw (Word variations have been searched)
#3	Yogi*:ti, ab, kw (Word variations have been searched)
#4	#1 OR #2 OR #3
#5	MeSH descriptor: [Randomized Controlled Trial] explode all trees
#6	Random*:ti, ab, kw (Word variations have been searched)
#7	#5 OR #6
#8	#4 AND #7
	IndMED
#1	(Yoga OR Yogic) and (Random OR Randomized OR Randomised OR Randomly)

2.4. Statistical Analysis. Data were analyzed using a standardized Microsoft Excel (version 12.3.5, Microsoft, Redmond, USA) spreadsheet [13] to calculate prevalence rates and standard errors. The Review Manager software package (version 5.2, Nordic Cochrane Centre, Copenhagen, Denmark) was used to conduct the meta-analysis on the basis of random effects to estimate weighted dropout rates with 95% confidence intervals (95% CIs) for the yoga groups and (if available) for the control groups. Subgroup analyses of dropout rates in the yoga groups were conducted for (1) study origin, (2) medical condition, (3) gender, (4) age group, (5) specific yoga techniques used, and (6) study duration. Subgroup differences were assessed by testing for heterogeneity across subgroups [14] using the I^2 statistics as a measure of the percentage of variability in effect estimates from the different subgroups that is due to genuine subgroup differences rather than chance. The Chi^2 test was further used and a p value ≤ 0.10 was regarded to indicate significant heterogeneity (see below).

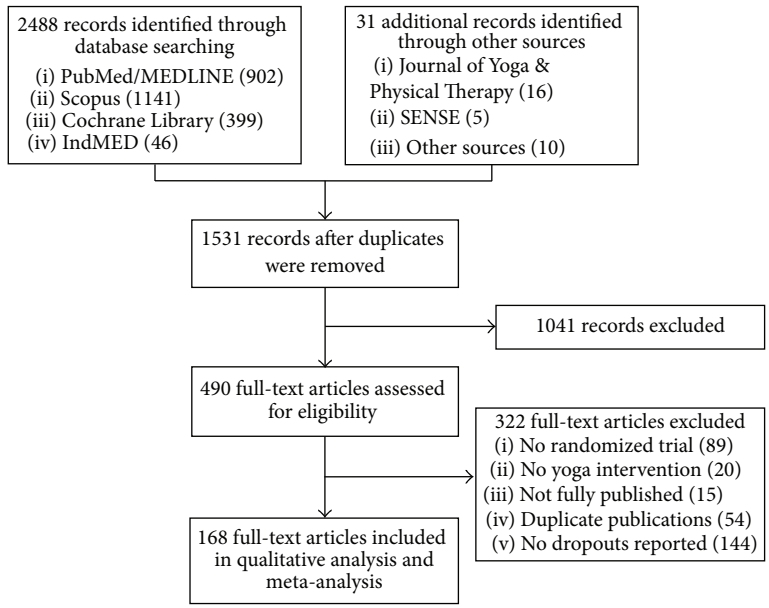

Figure 1: Flow chart of the results of the literature search.

Additionally, odds ratios (OR) with their 95% CIs were calculated to compare dropout rates between the yoga groups and specific control groups. Statistical heterogeneity between studies was analyzed using the I^2 statistics, a measure of how much variance between studies can be attributed to differences between studies rather than chance. The magnitude of heterogeneity was categorized as (1) I^2 = 0–24%: low heterogeneity; (2) I^2 = 25–49%: moderate heterogeneity; (3) I^2 = 50–74%: substantial heterogeneity; and (4) I^2 = 75–100%: considerable heterogeneity [14]. The Chi^2 test was used to assess whether differences in results are compatible with chance alone. Given the low power of this test when only few studies or studies with low sample size are included in a meta-analysis, a p value ≤ 0.10 was regarded to indicate significant heterogeneity [14, 15].

3. Results

3.1. Study Characteristics. Out of 312 located yoga RCTs, a total of 168 RCTs reporting dropout rates were included (Figure 1). Sixty-six RCTs (39.3%) originated from North America, 3 (1.8%) from South America, 20 (11.9%) from Europe, 69 (41.1%) from Asia, and 10 (6.0%) from Australia. While 47 RCTs (28.0%) included healthy participants, 121 (72.0%) included patients with medical conditions, mainly psychiatric (22 RCTs, 13.1%), musculoskeletal (21 RCTs, 12.5%), cardiovascular (16 RCTs, 9.5%), or oncological (16 RCTs, 9.5%) conditions. Most RCTs included both male and female (106 RCTs, 63.1%) or only female (49 RCTs, 29.2%) participants, only adult participants (82 RCTs, 48.8%), or mixed groups of adults and elderlies (67 RCTs, 39.9%). Median yoga group size was 30 with a range of 8 to 206. Control groups had median sample sizes of 39, 27, and 30 with ranges from 8 to 166, 5 to 204, and 10 to 99 for exercise, usual care, and psychological interventions, respectively.

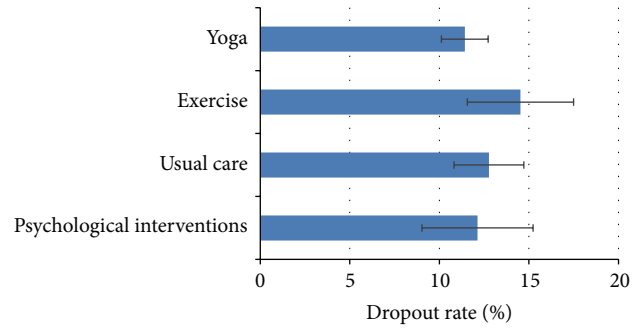

Figure 2: Overall estimated dropout rates (±95% confidence interval) for yoga and control interventions.

Regarding yoga interventions, yoga postures, breathing techniques, and meditation were used in 144 (85.7%), 130 (77.4%), and 86 RCTs (51.2%), respectively. 44 (26.2%), 89 (53.0%), and 35 (20.8%) RCTs used intervention durations of less than 8 weeks, 8 to 12 weeks, and more than 12 weeks, respectively.

3.2. Estimated Dropout Rates. Based on the 168 RCTs, overall dropout rate in the yoga groups was 11.42% (95% CI = 10.11%, 12.73%) (Figure 2). Dropout rates were similar in yoga compared to usual care (100 RCTs; rate = 12.77%; 95% CI = 10.82%, 14.72%; OR = 0.92; 95% CI = 0.79, 1.08) or compared to psychological control groups (34 RCTs; rate = 12.13%; 95% CI = 9.03%, 15.22%; OR = 0.86; 95% CI = 0.60, 1.22) but slightly lower in yoga compared to exercise control groups (41 RCTs; rate = 14.53%; 95% CI = 11.56%, 17.50%; OR = 0.82; 95% CI = 0.68, 0.98) (Figure 2, Table 2).

Dropout rates in the yoga groups did not differ between RCTs of different origin (p = 0.14; Table 3) but were higher for RCTs on patients with medical conditions (rate =

Table 2: Differences in estimated dropout rates between yoga and control interventions. CI: confidence interval; OR: odds ratio.

Comparison	OR [95% CI]	p value
Yoga versus exercise	0.82 [0.68, 0.98]	0.03
Heterogeneity: Chi^2 = 38.50, df = 40 (p = 0.54), I^2 = 0%		
Yoga versus usual care	0.92 [0.79, 1.08]	0.31
Heterogeneity: Chi^2 = 133.84, df = 102 (p = 0.02), I^2 = 24%		
Yoga versus psychological interventions	0.86 [0.60, 1.22]	0.40
Heterogeneity: Chi^2 = 57.09, df = 34 (p = 0.008), I^2 = 40%		

Table 3: Estimated dropout rates for yoga interventions as a function of study characteristics (country of origin). CI: confidence interval.

Country of origin	Number of studies	Rate [95% CI]
North America	66	11.79 [9.67, 13.92]
South America	3	3.07 [−3.73, 9.86]
Europe	20	13.79 [8.93, 18.64]
Asia	69	11.37 [9.35, 13.40]
Australia	10	11.69 [5.26, 18.11]
Test for subgroup differences: Chi^2 = 6.85, df = 4 (p = 0.14), I^2 = 41.6%		

Table 4: Estimated dropout rates for yoga interventions as a function of participant characteristics (medical condition, gender, and age groups). CI: confidence interval.

Condition	Number of studies	Rate [95% CI]
Medical conditions	121	12.48 [10.83, 14.13]
Healthy	47	9.34 [7.16, 11.51]
Test for subgroup differences: Chi^2 = 5.09, df = 1 (p = 0.02), I^2 = 80.3%		
Condition, specific	**Number of studies**	**Rate [95% CI]**
Musculoskeletal	21	7.54 [4.53, 10.55]
Cardiovascular	16	16.50 [11.03, 21.96]
Psychiatric	22	11.60 [7.38, 15.83]
Oncologic	16	18.04 [11.12, 24.96]
Pulmonary	9	12.95 [5.63, 20.28]
Neurological	10	12.87 [7.22, 18.52]
Endocrine	6	9.17 [1.75, 16.60]
Urogenital	10	11.94 [9.00, 14.89]
Digestive	2	0.83 [−2.90, 4.55]
Pregnancy	7	24.22 [12.38, 36.07]
HIV	2	22.20 [4.30, 40.09]
Test for subgroup differences: Chi^2 = 47.67, df = 10 (p < 0.00001), I^2 = 79.0%		
Gender	**Number of studies**	**Rate [95% CI]**
Male only	10	3.16 [−0.17, 6.50]
Female only	49	14.19 [11.36, 17.02]
Mixed gender	106	10.98 [9.37, 12.59]
Test for subgroup differences: Chi^2 = 25.44, df = 2 (p < 0.00001), I^2 = 92.1%		
Age groups	**Number of studies**	**Rate [95% CI]**
Children and adolescents only	7	5.62 [2.44, 8.80]
Adolescents and adults	2	26.61 [11.37, 41.85]
Adults only	82	11.20 [9.33, 13.06]
Elderlies only	10	10.06 [4.62, 15.50]
Adults and elderlies	67	12.86 [10.60, 15.12]
Test for subgroup differences: Chi^2 = 17.74, df = 4 (p = 0.001), I^2 = 77.4%		

12.48%; 95% CI = 10.48%, 14.13%) than for RCTs on healthy participants (rate = 9.34%; 95% CI = 10.48%, 14.13%; p = 0.02; Table 5). Regarding medical conditions, dropout rates differed strongly based on the specific condition (p < 0.01, Table 4), ranging from 0.83% (95% CI = −2.90%, 4.55%) for patients with digestive diseases to 22.20% (95% CI = 4.30%, 40.09%) for HIV patients. Likewise, dropout rates differed based on gender and age group with the highest dropout rates in RCTs including female participants only and in RCTs including both adolescents and adults (Table 4).

Regarding intervention characteristics, dropout rates were higher for RCTs that included yoga postures (12.00%, 95% CI = 10.53%, 13.46% versus 7.22%, 95% CI = 4.32%, 10.11; p > 0.01) and/or meditation (12.67%, 95% CI = 10.75%, 14.60% versus 10.07%, 95% CI = 8.25%, 11.89; p = 0.05) (Table 5) and gradually increased with intervention duration from 9.42% (95% CI = 6.93%, 11.91%) for a duration of less than 8 weeks to 15.23% (95% CI = 11.79%, 18.68%) for a duration of more than 12 weeks (p = 0.03; Table 5).

4. Discussion

4.1. Summary of Evidence. In this systematic review of 168 randomized controlled trials, on average 11.42% of all trial participants within the yoga groups dropped out during the trial. The dropout rates were mainly comparable to those in the other trial groups including usual care or psychological interventions; and they were slightly smaller compared to those in the exercise control groups. Differences in dropout rates were further found for patients with medical conditions compared to healthy participants and between patients with different medical conditions; for comparisons based on participants' gender and age; and for comparisons based on yoga's components and intervention duration.

Several findings deserve attention. First, the dropout rate in yoga groups at postintervention was relatively small. Given the rule of thumb that up to 20% of dropout during a trial can be considered acceptable [11], the majority of trials did not exceed this rate. The rate was further comparable to the rate in usual care or psychological interventions within the same trials precluding bias due to unbalanced dropouts in trial groups. Dropout rates are however slightly smaller than in exercise control groups indicating less attrition in the yoga study arms. Even though this analysis cannot provide sufficient explanation for this difference, it might be related to the recruitment process and the patients' preferences for either intervention.

Table 5: Estimated dropout rates for yoga interventions as a function of intervention characteristics (yoga postures, breathing techniques, meditation, and duration). CI: confidence interval.

Yoga postures	Number of studies	Rate, 95% CI
Including postures	144	12.00 [10.53, 13.46]
Not including postures	21	7.22 [4.32, 10.11]
Test for subgroup differences: $Chi^2 = 8.32$, $df = 1$ ($p = 0.004$), $I^2 = 88.0\%$		
Breathing techniques	Number of studies	Rate, 95% CI
Including breathing techniques	130	11.80 [10.27, 13.33]
Not including pranayama	34	10.63 [7.87, 13.40]
Test for subgroup differences: $Chi^2 = 0.53$, $df = 1$ ($p = 0.47$), $I^2 = 0\%$		
Meditation	Number of studies	Rate, 95% CI
Including meditation	86	12.67 [10.75, 14.60]
Not including meditation	78	10.07 [8.25, 11.89]
Test for subgroup differences: $Chi^2 = 3.70$, $df = 1$ ($p = 0.05$), $I^2 = 73.0\%$		
Intervention duration	Number of studies	Rate, 95% CI
Less than 8 weeks	44	9.42 [6.93, 11.91]
8–12 weeks	89	11.18 [9.42, 12.94]
More than 12 weeks	35	15.23 [11.79, 18.68]
Test for subgroup differences: $Chi^2 = 7.21$, $df = 2$ ($p = 0.03$), $I^2 = 72.3\%$		

As for the patients' characteristics, this analysis found that the dropout rate in healthy participants was significantly lower than in participants with medical conditions. And the condition itself may limit regular participation and adherence to yoga classes; we also found major differences between different patient subgroups. Patients diagnosed with oncological diseases or HIV and pregnant women, for example, had almost twice the dropout rate compared with patients with musculoskeletal disorders with upper borders of 95% CIs up to 40%. The severity of the medical conditions must therefore be considered an important factor when calculating the sample size for a trial [16]. The very low dropout rates in studies on digestive diseases [17, 18] may be explained by gender and age characteristics of the examined samples that included only male participants and adolescents.

Trials on only male participants had very low dropout rates while those including females only had more than four times as many. Trials with males only might however have used different settings, for example, the army forces [19] or workplace [20, 21]. These environments may have provided a specific structure and daily routine that increased compliance and adherence compared to other trials. Studies on females only also included those trials with pregnant women with high dropout rates, for example, due to pregnancy complications or onset of labor, thereby raising the average dropout rate for women in general. Moreover, most cancer-related trials were on female breast cancer patients [22–29] and associated with a relatively high dropout rate. It is therefore crucial to bear in mind the special circumstances for each trial when planning the respective study.

Furthermore, trials with children and adolescents only had very low attrition rates. This may be related to the settings of those trials, with studies being conducted in schools and colleges providing a suitable structure and daily routine for such trial. Interestingly, trials including both adolescents and adults had substantially higher dropout rates; however, the rate was calculated based on two trials only [30, 31]. So while this finding remains difficult to interpret, it seems advisable not to plan yoga interventions for adolescents and adults together.

Last but not least, the intervention characteristics played an important role in dropout rates. As for the intervention length, there was a clear association between the length of the intervention period and the dropout rate with almost double the attrition in trials over 12 weeks compared to trials up to 8 weeks. Such increase in dropout rates with increasing trial length is a common occurrence and can be observed in other nonyoga trials as well [16, 32]. As for the yoga components, trials incorporating yoga postures and meditation had higher dropout rates than those without those components. This is in line with findings that yoga-associated adverse events are often associated with specific yoga postures [33], although more adverse events have been reported for breathing techniques than for meditation.

The findings of this analysis may benefit future yoga research in many ways. For one it may present researchers with an estimate of expected dropout rates for future RCTs on yoga, taking into account several intervention or participant related factors. Findings from a large number of trials can thereby lead to a more accurate estimation of expected dropout rates than personal experience or rules of thumb can.

They may further enable researchers in specific scenarios to prepare for expected high dropout rates and to discuss strategies to successfully retain participants in the trial. Such strategies have been evaluated before in a variety of settings [34, 35].

Analyzing and comparing dropout rates during the trial can also provide information about the acceptability and safety of an intervention [32]. A recent meta-analysis however did not find any particular safety concerns associated with yoga, and rates of adverse events were comparable to that of exercise control interventions [36].

This study also faces some limitations. Only 168 of 312 RCTs (53.8%) could be included in the analysis; the other trials had to be excluded as they did not provide sufficient information about dropouts and withdrawal. Furthermore, only a minority of studies sufficiently described detailed reasons for dropouts. In order to judge whether the study may be biased (attrition bias), such information is as vital as the total number of dropouts. Due to the paucity of data, it was also not possible to analyze interactions between the study and participants' characteristics. Therefore, information on expected dropouts can only be considered a rough estimation.

Finally, researchers should be aware that there are many other factors influencing dropout rates, for example, the general setting (facility access), the study conditions (personnel, reimbursement of travel costs), and soft factors such as empathy of doctors and nurses.

4.2. Conclusion. Dropout rates usually can be expected to not exceed 15 to 20% in the majority of RCTs on yoga interventions. Yet dropout rates beyond 40% are possible depending on the participants' sociodemographic and health condition. This meta-analysis can serve as a guideline for sample size calculation in future RCTs on yoga interventions.

Competing Interests

The authors declare that there are no competing interests regarding the publication of this paper.

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