Research

Effectiveness of Somatic Yoga and Meditation: A Pilot Study in a Multicultural Cancer Survivor Population with Chemotherapy-Induced Peripheral Neuropathy

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Abstract

Chemotherapy-induced peripheral neuropathy (CIPN) causes significant pain and is an adverse effect of treatment with chemotherapeutic agents. We explored a somatic yoga and meditation intervention in a predominantly minority population. Goals included describing strategies for minority inclusion and testing feasibility and effectiveness. Eight individuals with CIPN enrolled in a single-arm feasibility trial. Somatic yoga and meditation were provided weekly for 8 weeks, with an additional home program component. The primary outcomes were Sit and Reach, Functional Reach, and Timed Up and Go. Secondary outcomes were Patient Neurotoxicity Questionnaire, FACT-GOG-Ntx (for addressing patient concerns associated with neurological symptoms), Brief Pain Inventory, Perceived Stress Scale, Pittsburgh Sleep Quality Index, and Falls Efficacy Scale. Sensitivity to vibration was measured via biothesiometer. Participants with a mean age of 65 (49–73) years self-reported as 63% African-American and 37% Caucasian. They attended 81% of the sessions, and no adverse events were reported. CIPN symptoms (FACT-GOG-Ntx) improved significantly (from 88.88 to 106.88, standard deviation = 20.03; p = 0.039). Fear of falling improved, approaching significance (from 39.26 to 34.38, standard deviation = 6.081; p = 0.058). Other measures showed improvement trends, with a slight increase in Brief Pain Inventory pain severity (from 3.50 to 3.75, p = 0.041) possibly reflecting comorbidities. Four qualitative themes emerged: (1) CIPN symptom variability, with musculoskeletal comorbidities; (2) utility of learned skills; (3) improvement in self-confidence, balance, and stability; and (4) social support, with CIPN experience validation and increasing health literacy. Challenges of recruitment and retention require specific outreach, community trust, and health literacy. Preliminary data suggest that somatic yoga and meditation may affect fear of falling and quality of life in cancer survivors with CIPN. A randomized controlled trial using inclusive recruitment and retention methods is indicated to establish the intervention's efficacy. *Galantino et al. Int J Yoga Therapy 2020(30). doi: 10.17761/2020-D-18-00030.*

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Introduction

Yoga is a popular movement therapy often used by cancer survivors for symptom management, with effects on physical and mental health.[1–3] Integrative therapies are used to mitigate side-effects of treatment, and many studies demonstrate the positive findings of yoga on several domains of quality of life (QOL).[4] However, previous studies focused predominantly on Caucasian, suburban, female, middle-aged breast cancer survivors experiencing various side-effects of treatment, with little generalizability of these findings to other cancer populations.[1,5] A previous cross-sectional study indicated that cancer survivors who integrate yoga into their care are predominantly white, with lower body mass index (BMI) and higher education levels.[6] Minorities, males, those with higher BMI, and those with less education are underrepresented in research on yoga in cancer survivors.

Although yoga studies for cancer survivors address various impairments, no study has rigorously investigated the effectiveness of yoga for diminishing the side-effects of chemotherapy-induced peripheral neuropathy (CIPN) in a predominantly minority population. CIPN is a prevalent side-effect of commonly used chemotherapies and reduces QOL in individuals diagnosed with cancer, including breast, colon, lung, and lymphoma.[7] CIPN causes loss of proprioception and reduction of optimal ambulation alongside significant pain in the hands and feet.[7] It is a common dose-dependent adverse effect of several commonly used chemotherapeutic agents and can affect the outcome of treatment and compromise survival, including by increasing fall risk.[8]

Clinically, CIPN most commonly presents as alterations in sensation perception that develop in a glove and stocking distribution, but it may also present as motor and autonomic dysfunction.[9] Walking speed and balance may be compromised, and these functional deficits are evident with increased patient-reported symptom severity[10] and may be associated with potential fall risk and functional disability.[8] Despite CIPN's emergence as an important clinical side-effect, few interventions have been tested for their effect on its symptoms, particularly in minority cancer survivor populations. In previous research with breast cancer survivors, we found that yoga improved musculoskeletal symptoms of the side-effects of aromatase inhibitors used for treatment of breast cancer survivors.[11,12] The current study was conducted to explore inclusive recruitment in a predominantly urban and surrounding area population of cancer survivors to further understand factors influencing underrepresented populations in cancer trials for yoga. We explored the preliminary therapeutic effects of an 8-week somatic yoga and meditation (SYM) program for functional outcomes and QOL among individuals with CIPN.

Methods

Participant Recruitment and Inclusion/Exclusion Criteria

Recruitment occurred through several venues to decrease recruitment bias and included physical fliers, email, local and regional radio, social media posts, and word of mouth, with increased targeting to urban locations. Fliers in both English and Spanish were placed in local oncology-related physician offices and emailed to physicians and office managers (including those in primary care, medical oncology, radiation oncology, surgery, plastic surgery, rehabilitation), and to integrative therapists including acupuncturists and yoga professionals. Fliers were also made available in public establishments, including supermarkets, libraries, corner markets, and coffee shops; through the urban yoga studio hosting the study; and through a local cancer support community, with active recruitment through the support group's meeting near the urban center. The Stockton University and Bacharach Institute for Rehabilitation institutional review boards (IRB) both approved the study protocol.

Inclusion criteria included cancer survivors age 18 or older; any type or stage of cancer, with all treatment completed and no current evidence of disease; and at least mild peripheral neuropathy symptoms (either sensory or motor) as rated on the Patient Neurotoxicity Questionnaire (PNQ) and attributable to chemotherapy intervention as a component of cancer treatment. Exclusion criteria included active cancer disease or current cancer treatment; comorbidities implicated as contributory to peripheral neuropathy (e.g., diabetes mellitus) or prior history of peripheral neuropathy from other diseases; and any cause of concern for adverse events with initiating exercise determined by pre-study screening using the Physical Activity Readiness Questionnaire (PAR-Q). All participants were screened in advance of eligibility testing to determine the safety or possible risk of exercising with this brief seven-question tool, with physician clearance obtained prior to the start of the trial intervention for any participant with a health risk or concern as triggered by this patient-reported questionaire.[13]

Data Collection and Primary Clinical Outcome Measurements

The Sit and Reach (SR) test measures hamstring and low-back flexibility through a maximal reach in a seated extended-knee position.[14,15] The SR has established norms, with a score of 16 cm and 15 cm for adults 46–55 years old and 56–65 years old, respectively, in the 50th percentile.[6,16] Subjects are asked to maintain a "long-sit" position on the floor while safely reaching forward as far as possible with their shoes removed, feet flat against a box, and legs straight. A chair-seated modification was available for those unable to transfer safely to the floor.[17,18] Maintaining flexibility may prevent acute and chronic musculoskeletal injuries, low-back problems, postural deviations, gait limitations, and risk of falling.[18]

The Timed Up and Go (TUG) tests physical function in sitting to standing, walking 3 meters, and returning to the seated position, with results recorded in seconds.[19,20] Worse performance is indicated with longer time to completion. Participants are instructed to stand up from a chair, walk 3 meters as quickly and safely as possible, turn around, walk back, and sit down. Results of 9 seconds and above indicate a high risk of falls.[21]

The Functional Reach (FR) test examines balance with respect to the patient's limit of stability. The participant is instructed to flex the dominant arm forward to 90 degrees and to reach forward as far as possible before taking a step.

The reach is determined by the total excursion of the third metacarpal from the starting point to the point just before balance is lost, with the average of three measurements in centimeters used as the final score.[22] FR has demonstrated strong reliability and validity for measuring postural control in reaching forward during standing and demonstrates excellent psychometric properties.[23,24] It predicts fall risk[22] with reaches of less than 25.4 cm.[25] Both FR and TUG can be used to track changes in balance performance and fall risk over time.

The SR,[26,27] TUG,[19,20] and FR[22,28] were evaluated by research assistants and clinically assessed at baseline and 8 weeks. Interrater reliability was assessed between three investigators (85% kappa coefficient). These measures served as primary clinical outcomes, have been used in previous yoga studies, and are sensitive to functional changes over time.

Data Collection and Secondary/Patient-Reported Outcome Measurements

Pain (Brief Pain Inventory [BPI][29]), quality of life specific to CIPN (Patient Neurotoxicity Questionnaire [PNQ],[30] Functional Assessment of Cancer Therapy–Neurotoxicity [FACT-GOG-Ntx][31]), stress (Perceived Stress Scale [PSS]),[32] sleep (Pittsburgh Sleep Quality Index [PSQI]),[33,34] Functional Assessment of Chronic Illness Therapy–Spirituality (FACIT-Sp),[35] and fear of falling (Falls Efficacy Scale [FES])[36] were measured using valid and reliable patient-reported outcomes. The FACT-GOG-Ntx[31] and PNQ[30] were used as the CIPN evaluation method.[33,34,37]

Vibration sense was measured on the feet through a calibrated biothesiometer.[38] Participants were placed in a relaxed position in a chair and tested with the same script and application of the vibration unit to the proximal lower extremity where sensation was intact to demonstrate the vibration stimulus. The midplantar pad and the tip of the great toe were tested per protocol, with visual feedback reduced to eliminate false-positive responses. Results were recorded in microvolts (μV). Primary clinical outcome measures, participant-reported outcome surveys, and vibration sense were administered at baseline and at week 8.

Finally, participants were asked to write in journals to reflect on class and home practice for qualitative analysis. Weekly verbal and/or telephone check-ins, mid-study debriefing, and end-of-study roundtable discussion also occurred. Guiding questions for journaling included the following:

1. What type of practice was it? Home or class?
2. What was most enjoyable?
3. What was most challenging?
4. Describe your symptoms or how you feel.
5. What was most beneficial?

Study Intervention

Hatha Yoga is broadly recognized as a genre of yoga that has a reproducible format; combines postures *(asana),* breathwork *(pranayama),* and meditation; and can be used therapeutically in the healing of a wide variety of conditions.[39] This healing is facilitated by Hatha Yoga's ability to elicit the relaxation response through engagement of the parasympathetic nervous system.[39] This therapeutic pathway is of particular importance for individuals in cancer recovery, as it counters the adverse effects of the sympathetic nervous system's stress response, allowing multisystem body and mind integration and healing.[40–42] Hatha yoga's emphasis on dynamic movements in connection with breath leads to improvement in flexibility, strength, stability, and balance, all of which may be negatively affected by cancer treatment.[43]

What makes individuals with CIPN unique from others in cancer recovery is additional pain in the hands and feet, which reduces proprioception and sensation, resulting in extremity disembodiment. To address these additional symptoms, a somatically based yoga protocol was used to foster cognitive awareness and extremity reintegration. The protocol was inspired by the principles of Hanna Somatics (Thomas Hanna) and Somatic Yoga (Eleanor Criswell), both rooted in Hatha Yoga.[44–46]

Somatic methods incorporate neurophysiology, psychophysiology, and mindfulness for increased mind-body integration and are grounded in ideas from the biofeedback literature.[45,47] Hanna described soma as the body perceived from within.[48,49] With CIPN, this perception is lost over time, and muscles are potentially both weakened and contracted from chronic stress.[50] These states of contraction cause ongoing symptoms such as poor posture, decreased flexibility and balance, debilitating pain, and overall decreased quality of life.[51] This chronic contraction needs to be relieved before muscle strengthening can be achieved. Stretching only temporarily passively lengthens a muscle as the stretch reflex at the spinal cord level causes the muscle to recontract. The movement of traditional yoga stretches muscles. Somatic Yoga, on the other hand, is an active process that consciously engages and reeducates the brain in neuromuscular movement, increasing the resting length of chronically contracted muscles. This is achieved both by directing attention to one's own internal sensations of movement, creating a first-person experience, as well as through pandiculation.[45,52]

The movements use pandiculation—voluntary muscular contraction and slow, controlled decontraction (eccentric contraction), with constant focus on sensation—to achieve this first-person experience and to increase the resting length of muscles.[53] When the resting length of a muscle is increased, there is less tension in the muscle, less

compressive force of that muscle on adjacent structures, greater circulation of blood and lymph, and overall more comfort in the body. Pandiculation reawakens the sensorimotor system and improves proprioception. Movements are performed slowly, gently, and comfortably with the least possible effort and are never forced.[44,45,51] To ensure a first-person experience and to lessen the use of mirror neurons, which invoke a third-person experience, yoga instructors repeatedly use verbal cues with each movement to draw particular attention to a felt sense of that movement during both voluntarily controlled muscular contraction and decontraction. Focus on the felt sense draws attention to the body, calming the thinking mind and further enhancing the relaxation response.

The protocol includes iRest® yoga nidra–inspired guided meditations from the Integrative Restoration Institute. This genre of guided meditation is somatically based, as participants are led to focus on the felt sense of their experiences, encouraging embodiment. In 2010, iRest® was endorsed by the U.S. Army Surgeon General and Defense Centers of Excellence as treatment for chronic pain.[54] These meditations, developed by Richard Miller, PhD, are trauma-informed and evidence-based, supporting healing, personal growth, and well-being over a broad range of populations including individuals with cancer.[54–56] With relief of psychological stress, there is a greater chance for recovery of muscular function and somatic sensation.[57]

Participants met once per week for 8 weeks, and sessions were taught by registered yoga teachers. The SYM program lasted 90 minutes per class and was structured as shown in Table 1, with individual variations to maximize the safety of the participants at their current functional status level. Our protocol was created by a physician and certified yoga therapist (RT), who holds specialty certifications with Integrative Yoga Therapy, The Novato Institute for Somatics Research and Training, Trauma Informed Yoga Therapy, Yoga 4 Cancer, and Integrative Restoration Institute.

Yoga instructors were trained by the protocol designer using multiple methods of instruction and verification. In addition to verbal education in the protocol sequence and supporting theory, the instructor team experienced the protocol in their own bodies, with and without the use of variations and props. The instructors were provided with yoga and meditation protocol handouts to follow and were offered support as needed throughout the study. The yoga instructor team ensured the safety and comfort of each participant throughout each class, including assisting with the use of props such as blocks, mats, blankets, chairs, and pillows as needed. Participants were encouraged to honor how they were feeling in each moment and to only move and breathe in a way that felt comfortable. They were facilitated in choices to use props during the study, with guidance to reflect any self-led progression in decreasing use of props to assume greater challenges or increasing use of supports to foster symptom relief, relaxation, and ease in more symptomatic moments. Overall, this program was designed to decrease CIPN symptoms, including pain, numbness, and tingling in the extremities, with resultant improvement in flexibility, strength, proprioception, agility, balance, and kinesthetic sense.

Table 1. Yoga Class Structure and Components

Asana/Activity	Time (min)
Seated	
Verbal checkin, address inquiries	5
Supine	
Prepractice body and breath scan[51(pp. 44–45)]	2
Belly breathing, two-part breath, set intention	4
Somatic movements:	15
• Arch/flatten back[44(pp. 101–102),51(pp. 46–47)]	
• Arch/curl[44(p. 105),51(pp. 46–49)]	
• Twists[44(pp. 120–121),51(pp. 69–71)]	
• Hip series[44(pp. 123–108),51(pp. 80–85)]	
Knees to chest, knee circles	1
Seated *sukhasana* (cross-legged)	
Cleansing breaths	1
Finger fan	1
Chin mudra[110(pp. 204–205)] with *kaki* (beak) exhale breath	2
Sun breaths with neck stretches	2
Dandasana (staff pose): joint-freeing series ankles/feet, forward folds[111(pp. 132–133)]	4
Switch sukhasana (cross-legged): joint-freeing series wrist/elbow/shoulder[111(pp. 132–133)]	4
Side bends	2
Tabletop/ hands-and-knees	
Marjariasana (cat/cow) to center, left, right	2
Chakravakasana (sunbird) to *balasana* (child's pose)	2
Tadasana (standing mountain pose)	
Toe fan	1
Dancing warrior series *(virabhadrasana)*	4
Tree pose *(vriksasana)*	4
"Shake tree" qi gong[112]	1
Cleansing breaths	1
Supine (or seated variation)	
Twists	2
Bridge	1
iRest® yoga nidra–inspired guided meditation[54]	20
Savasana (corpse pose/"resting pose")	5
Postpractice body and breath scan, noting changes	2
Seated	
Mandala (circle) mudra with affirmation "I am complete and whole exactly as I am"[110(pp. 216–217)]	1
Sun breath, anjali mudra (palms together at heart), OM, *namaste*[110(pp. 260–261)]	1

Abbreviated versions of the SYM program were introduced for home practice during week 1 of the structured sessions, along with handouts summarizing the yoga practice and a simple "20 breath meditation"[58,59] encouraging focus and mindfulness to each breath. Four recorded audio files were emailed to participants and made available by CD for those without email access. Support was offered by the research team to verify that all participants were able to access the four files. Two recordings were an abbreviated home yoga practice, used with or without a chair depending on the needs of the individual. Two additional recordings were short and long iRest® yoga nidra–inspired guided meditations.[54,55]

Adding a home program fosters improved self-sufficiency. Additionally, this small amount of daily practice has been used in other mind-body therapy trials.[60,61] These SYM practices were chosen because they are simple and require minimal props including blankets, pillows, or chairs, as used in the class environment. Adherence to the home-based SYM program was measured weekly by discussion with a research assistant. Additionally, participants recorded their daily practices in a journal and provided insights into their experiences with the SYM classes and home practices.

Data Analysis

SPSS 24.0 was used to examine paired *t* tests and Wilcoxon rank-sum tests for all variables. For the qualitative data, content analysis was used and involved individual coding based on variables identified. Journals and transcriptions of mid-study debriefing and end-of-study roundtable discussion were reviewed, and codes were assigned and entered. The qualitative data were recorded from weekly research assistant checkins or phone calls and yoga teacher observations and entered into Microsoft Excel. The investigators' notes taken during the weekly encounters were compiled and reviewed by the research team for any additional relevant information and confirmatory statements.

After the journals, transcriptions, and other information sources were read in detail twice by all the researchers, main themes were identified and coded with an iterative process. Corresponding quotes were entered into Microsoft Excel to create tables identifying the main themes. The research group compared each result to establish good inter-rater reliability (kappa 90%) within the recurring themes. There were no outliers or insignificant themes, and the researchers came to consensus on each identified theme. A member check was performed to enhance the internal validity of the results. The ability to triangulate with journals, weekly encounters, transcriptions of interviews, and observation by the yoga instructors and researchers further confirmed these findings.

Results

Patient Characteristics

Between July and October 2018, 28 individuals were referred because of CIPN symptoms or responded to flyers or publicity about the study. Of this group, 11 initially passed telephone or in-person screening for participation. One participant did not complete intake testing and opted not to participate because of limitations in possible attendance. Ten participants consented to participation in the study and signed the IRB-approved consent form. Two of the individuals did not complete formal prestudy screenings and exited the study because of health-related changes. Eight individuals completed intake and prestudy screening and testing. Five participants participated in a midstudy debriefing, and seven participated in a poststudy roundtable discussion. One participant did not complete end-of-study testing. Intention to treat was used for all data analyses.

The mean age of the participants was 65.0 years, ranging from 49–73. Five participants identified as Black/African-American and three as Caucasian. Seven were female, and one was male. Four participants had a diagnosis and treatment for breast cancer, two had colon cancer, one had ovarian cancer, and one had pancreatic cancer. Four participants reported that they were stage II, one was stage I, one was stage III, and two were unsure of their definitive staging. Three reported their most recent chemotherapy as less than 1 year ago, one as 5 years or less, two as 10 years or less, and two as over 10 years ago. One participant was employed part-time, one was on current medical leave, one was permanently disabled, and five were retired.

Baseline self-reported PNQ revealed one participant rated sensory symptoms (e.g., pain, numbness, burning, and/or tingling) as *mild,* with two rating as *moderate,* four rating as *moderate to severe,* and one rating as *severe.* Additionally, one participant self-rated muscular weakness as *severe,* four rated as *moderate to severe,* one as *moderate,* and two as *mild* (Table 2).

Overall attendance was 81%, ranging from five to eight sessions, with absences primarily attributed to inclement weather, lack of transportation, or health reasons. Seventy-five percent (6/8) trialed the home program (meditation/breathwork and/or yoga-based movement). Four performed the home program component at least once a week, with two performing the home program at least three times a week. Seven of the eight participants included self-selected aspects of the breathing, meditation, or somatic-based yoga movements on a daily basis to address physical, emotional, or neurogenic symptoms or issues.

One participant had lymphedema in the left upper and bilateral lower extremities at baseline, with five others at elevated risk due to history of nodal dissection and/or

Table 2. Patient Neurotoxicity Questionnaire Outcomes (n = 8)

Measure	Baseline	After Yoga Intervention
Mild numbness, pain, and tingling	1 (12.5%)	2 (25%)
Moderate numbness, pain, and tingling	2 (25%)	2 (25%)
Moderate to severe numbness, pain, and tingling	4 (50%)	3 (37.5%)
Severe numbness, pain, and tingling	1 (12.5%)	1 (12.5%)
No weakness	0 (0%)	1 (12.5%)
Mild weakness	2 (25%)	1 (12.5%)
Moderate weakness	1 (12.5%)	2 (25%)
Moderate to severe weakness	4 (50%)	4 (50%)
Severe weakness	1 (12.5%)	0 (0%)

radiation therapy with no current reported lymphedema in the at-risk limbs. A certified lymphedema therapist was available to all participants through this study if needed; however, there was no exacerbation observed or reported throughout the study. Three participants reported chronic pain–related diagnoses at baseline that required adaptation throughout the yoga sessions, yet no worsening of these conditions was attributed to the SYM protocol. There were no adverse responses or events during the course of the study.

Primary Clinical Outcomes Measures

Participants had trends of improvement in flexibility measured by SR (mean reduction 3.20, standard deviation [SD] 5.33, p = 0.133) and in balance measured by FR (mean reduction 1.45, SD 7.41, p = 0.597). The TUG improved in gait speed, balance, and fall-risk reduction (mean reduction 1.16, SD 1.84, p = 0.119) (Table 3). Three of the eight participants were at high risk for falls using the TUG at intake, with only one participant remaining at fall risk by the end of the study.

Secondary and Patient-Reported Outcomes Related to Pain and QOL

Subjects experienced a slight increase in BPI pain severity (3.50 to 3.75, p = 0.041), which may reflect influences from musculoskeletal comorbidities, delayed-onset muscle soreness, or perceived increase in sensation. CIPN symptoms measured by the FACT-GOG-Ntx demonstrated significant improvement (88.88 to 106.88, SD 20.03, p = 0.039), indicating improvement in QOL. The intake measure of CIPN symptoms, PNQ, showed improvement in sensory symptoms and muscular weakness (3.56 to 3.31, p = 0.316). Fear of falling (FES) improved considerably, approaching significance (39.26 to 34.38, SD 6.081 p = 0.058). Stress (PSS) was reduced (15.75 to 15.00, p = 0.608), with sleep quality (PSQI) improvements also shown (9.75 to 9.38, p = 0.644). Spirituality, as measured by FACIT-Sp, also improved (101.75 to 115.63, p = 0.496).

Table 3. Change in Clinician-Measured Outcomes, Patient-Reported Surveys, and Biomarkers (n = 8)

Measure	Baseline, Mean (SD)	Week 8, Mean (SD)	*p* Value
Clinical functional measures			
FR	33.97 (8.07)	35.42 (9.88)	0.597
SR	26.23 (8.00)	29.43 (9.60)	0.133
TUG	10.75 (5.44)	9.59 (4.89)	0.119
Patient-reported outcomes			
PSS	15.75 (10.49)	15 (9.16)	0.608
FES	39.25 (13.30)	34.38 (14.16)	0.058*
BPI severity	3.46 (2.97)	3.75 (2.89)	0.609
BPI interference	3.80 (3.41)	3.54 (3.39)	0.687
FACT-GOG-Ntx	88.88 (38.30)	106.88 (30.95)	0.039*
FACIT-Sp	101.75 (42.88)	115.63 (38.96)	0.130
PSIQ	9.75 (3.41)	9.38 (4.13)	0.644
PNQ	3.56 (0.86)	3.31 (0.92)	0.316
Biothesiometer—(vibration)			
Right midplantar	37.25 (11.23)	32.00 (12.13)	0.125
Left midplantar	39.75 (11.72)	31.75 (12.34)	0.127
Right tip of great toe	37.88 (12.65)	36 (9.21)	0.507
Left tip of great toe	41.25 (10.45)	34.63 (11.36)	0.950

*p < 0.05.

SD = standard deviation; FR = Functional Reach test; SR = Sit and Reach test; TUG = Timed Up and Go; PSS = Perceived Stress Scale; FES = Falls Efficacy Scale; BPI = Brief Pain Inventory; FACT-GOG-Ntx = Functional Assessment of Cancer Therapy–Neurotoxicity quality of life; FACIT-Sp = Functional Assessment of Chronic Illness Therapy–Spirituality; PSIQ = Pittsburgh Sleep Interference Scale; PNQ = Patient Neurotoxicity Scale.

Vibratory sensation perception as measured via biothesiometer demonstrated trends of improvement in all tested locations on the feet, which is of particular interest given the relatively short duration of this 8-week SYM study (Table 3).

Qualitative Data

Four themes emerged from journal entries, weekly checkins, midstudy debriefing, and final roundtable discussion and were substantiated among the participants through member checks: (1) variation of CIPN pain symptoms, coupled with musculoskeletal comorbidities; (2) utility of learned skills, applied to everyday life situations; (3) improvement in self-confidence, balance, and stability; and (4) social support, with validation of CIPN experience and increasing health literacy.

Variation of CIPN pain symptoms, coupled with musculoskeletal comorbidities

Participants reported variation in CIPN symptoms and intensity influenced by multiple factors including unrelated musculoskeletal comorbidities such as osteoarthritis and chronic pain disorders. The majority of participants (7/8) reported decreased CIPN symptoms with participation in the SYM study.

> I have found remarkable positive results from the yoga and meditation. The pain and numbness in my feet has lessened substantially. —P1

> When I take my shoes off, I am able to put them back on without a lot of trouble. My feet are feeling so much better from doing the yoga. —P3

> The muscle relaxation helped me; as far as the neuropathy, it did not help. —P4

> I can say since I've started this study that my feet [have] gotten better but I do still have my up and down days. —P5

> My neuropathy is significantly reduced for at least 2 to 4 hours after a session. —P7

> Today I noticed some of the numbness in my left foot and toes has eased up. I can feel them when I walk now. What a blessing. —P8

Utility of learned skills, applied to everyday life situations

Application of the tools learned through participation in the SYM protocol, including components of the somatic movements, particular yoga poses, the SYM component recordings, or breathing techniques, modified participants' experience of physical, psychological, and/or neurogenic symptoms. During the poststudy roundtable, the majority (7/8) of participants confirmed daily use of self-selected breathing techniques and/or stretches for effective symptom and anxiety reduction.

> I still wake up early with pain in feet and legs but now use the breathing exercises, which relaxes me during the day, and try to use the yoga to help with hands and feet. —P1

> I have been doing the "20 breaths" practice during the days at some point . . . I find it a good stress reliever and will continue. This is my favorite and most beneficial. —P2

> I used the breathing to get through my MRI. —P5

> I noticed that I get more from using the nebulizer during my breathing treatment now that I do the breathing exercises. —P8

Improvement in self-confidence, balance, and stability

All participants (8/8) reported some level of improvement in balance and walking stability during the course of the study. A consistent majority (7/8) confirmed a definitive increase in balance, stability, and self-confidence during the poststudy roundtable, with various comments of increased community integration and reduced fear of falls.

> The most challenging is the balancing, which I can say has improved a lot. —P5

> You know I still have balance issues, but, over the course of the 8 weeks, by doing the yoga it has minimized my problem with balance. —P7

> I have less fear of falling now, because I had two falls before. —P8

Social support, with validation of CIPN experience and increasing health literacy

All participants (8/8) expressed validation of their CIPN-related symptoms and deficits throughout the course of this study, with appreciation of the sense of community, support, and education provided by the other participants, SYM class leaders, and researchers. Three participants verbalized intent to seek care/physical therapy to address unrelated health issues implicated in functional deficits. One participant independently initiated healthful eating habits, with weight loss of 14 pounds reported at the final session. One participant reported seeking yoga teacher training to expand her own practice and increase options available in the local area for other at-risk populations.

> I had not been made aware that the chemo treatment I received could cause neuropathy and actually thought I was crazy until being a part of this study and having the opportunity to speak to and relate to other people that are suffering with CIPN. —P1

> Most enjoyable. Knowing I will have . . . therapy specifically developed for cancer survivors' chemo effects. —P6
>
> I will miss the friendly, positive energy from the instructors and the group. —P8

Discussion

The American Society of Clinical Oncology provides evidence-based guidance on the optimum prevention and treatment approaches in the management of CIPN in adult cancer survivors. Our participants reported chemotherapeutic treatment of their cancers with interventions including taxanes,[62] platinum-based drugs, and vinca alkaloids. Unfortunately, 50% percent of all leukemia, lymphoma, colorectal cancer, and breast cancer patients experience CIPN,[63–65] and time to address this condition appears to be delayed by years. Previous work has suggested that patients often underreport CIPN symptoms and physicians fail to recognize the presence of such symptoms in a timely fashion.[66] Our participants did not make physical connections between chronic CIPN, additional chronic musculoskeletal issues, and interrupted sleep. Although no agents aside from duloxetine are available to prevent this painful condition, diligent attendance to screening for CIPN is prudent and strategies for dose-limiting treatments imperative. Drug trials are inconclusive regarding treatment for neuropathic pain syndromes[67]; therefore, a biopsychosocial approach to chronic pain, including SYM, is necessary.

The extensive use of integrative medicine among cancer survivors is well-documented in the literature.[14,68–72] Yoga combines postures, breathing exercises, and meditation to foster connection between mind and body. Given significant chronic pain in our study participants, we noted several comorbidities in addition to the primary cancer diagnosis. The conceptual model proposed by Sherman et al. suggests that posture training may improve strength and flexibility, meditation may decrease stress/anxiety associated with pain, and the relaxation response related to breathing and overall practice of yoga may result in modulation of the neuroendocrine system through the hypothalamic-pituitary-adrenal (HPA) axis.[16,107] Given the benefit of social connection, the group activities and active engagement of the whole person in a movement/meditation practice may change cognitive appraisal and improve self-efficacy related to chronic pain.[74] In addition, the positive effect of SYM group activity was confirmed through participant QOL (FACT-GOG-Ntx) and our qualitative data.

Although most yoga studies include evidence for management of treatment-related toxicities, this is the first to explore the effect on survivors with CIPN with purposeful inclusion of minority participants with multiple comorbidities. Yoga positions and relaxation breathing have been found to significantly reduce fatigue and pain levels in addition to increasing levels of invigoration, acceptance, and relaxation.[75–77] However, subjective variation in pain reveals the complexity of CIPN and the resultant musculoskeletal changes leading to compensatory movement patterns. Most participants described undulating changes of their pain throughout 8 weeks. Several participants verbally expressed their wishes for a longer study, noting significant qualitative improvement commencing in the last few weeks of classes. Perhaps duration of once per week for 8 weeks is not a sufficient dosage to attain a sustainable change; we would recommend offering classes either more often or for a longer duration to foster optimal dosage, given the unique challenges in the urban environment.

Our pilot research shows that participants experienced several physiologic benefits from SYM. The addition of an intentional somatic component of this yoga protocol fostered greater sensory and proprioceptive improvement and easily accessible motion for individual participants. Repetitive movement patterns through various asana have been found to restore biological rhythmicity disrupted by stress from an overactivated sympathetic nervous system and HPA axis.[24,77] Meditation fosters deep relaxation and stress relief cognitively by improving self-control and attention skills, emotionally by creating a positive mood and emotional stability, and psychologically by enhancing psychoemotional balance.[78]

The results of yoga therapy research inform guidelines and standards of care that lead to improvements in management of lingering side-effects from cancer treatment. However, minorities and the underserved, especially the aging members of these demographic groups, are underrepresented in oncology clinical trials.[79,80] The situation is more complicated when the toxicity of chemotherapy disproportionately affects an underrepresented population.[81–84]

Yoga is a commonly used intervention among cancer patients, especially within breast cancer survivors.[85] However, the women in yoga clinical trials are predominantly white, with lower BMI and higher education levels.[6] Multiple factors contribute to the lack of minority recruitment. In general, eligibility, health systems, and healthcare providers are noted obstacles in minority participation in cancer clinical trials.[86] Participant-related barriers include lack of trust of the medical system, costs incurred, and uncertainty about randomization.[87,88] Physician-level barriers include lack of time to enroll or refer to clinical trials, preferences in specific treatment for patients, and biases that certain patients will not be interested or adherent.[89–92] Systems-level barriers include accessibility to a clinic with clinical trials and availability of applicable clinical trials.[93–95] Perspectives of cancer center clinical and research personnel

indicate barriers to minority recruitment, including distrust in research based in historical abuse and discrimination, unmet transportation needs, and the negative connotation of clinical trials.[96] Lack of insurance and language barriers also reduce the likelihood that providers will offer opportunities to participate in clinical trials. Other barriers may include access to a working telephone, schedule conflicts, and a caregiver role that limits availability.[97] Increasing awareness of opportunities and barriers is essential for the enhancement of minority enrollment, and key community partnerships are important.

Facilitators need to accommodate cultural needs, desires, and stated biases in addition to addressing everyday practical needs such as transportation or lodging. Internal referrals, such as communication with and education of patients, may increase potential minority recruitment. However, the benefits to this approach may be limited by the number of multicultural patients with access to tertiary cancer treatment centers offering clinical trials. Establishing relationships with healthcare centers with large minority client bases may improve minority recruitment. Our study found similar needs for outreach to local cancer centers, transportation, and attention to reminders for classes and home SYM practice options at varying physical ability levels.

Historically, African-Americans are less willing to participate in clinical trials compared to their Caucasian counterparts and generally assign negative connotations to such studies. They are more likely to participate in clinical trials, regardless of race, if they trust the people recommending the clinical trial (healthcare professional, researcher, friend, or relative).[97] In our study, medical clinicians, support group facilitators, and known community leaders encouraged participation in SYM for management of neuropathy pain from chemotherapy side-effects.

Additionally, faith and specific spiritual beliefs may be deterrents to successful recruitment, while in some cases, these same entities may serve as a source of recruitment and trust building.[97] To improve recruitment of individuals identifying as minorities, several accommodations were found effective, including a multicultural research team, translators, and bilingual materials and classes, along with decreasing what might be deemed "spiritual" aspects of yoga.[97] Participants may also be more comfortable taking yoga classes from teachers with diverse racial/ethnic backgrounds.[98] Tailoring the recruitment protocol to meet cultural and language needs may increase recruitment of minority populations. Our study took place in an urban yoga studio setting that included cultural diversity among research assistants and yoga instructors trained in the CIPN protocol, where modifications were offered to meet the needs of participants with multiple complex comorbidities.

Cancer survivors who report muscle weakness, loss of balance, and long-term persistence of mobility decline may be at elevated risk for falls.[10,99,100] Our study showed that we were able to reduce measurable fall risk (TUG) through SYM in two of our three participants at high risk for falls, with the majority reducing their fear of falling. Given the severity and length of CIPN symptoms in our population, several participants had experienced falls. Our qualitative findings support previous research in which participants initially described variability in neuropathic symptoms, muscle weakness, and loss of balance.[101] This variation in symptoms interfered with activities of daily living, including falls, and participants shared feelings of frustration and loss of enjoyable activities.[102] Our study was able to demonstrate a renewed interest in activities and overall improvement in function and QOL. In addition, our participants improved in mobility, balance, and fall risk as measured through TUG. Balance and fall risk directly correlate to functional outcomes and potential disabilities. Other associated comorbidities or chronic pain status may affect balance, including postural instability.[103] Additionally, SYM improved vibration sense with emphasis placed on body awareness and sensation perception. This increased sensation directly affects activation of the foot-ankle complex with biomechanical gait improvements. Quantitative gait analysis would be recommended in future studies to further investigate.

Evidence of yoga's efficacy for symptom management in cancer survivors is growing[3,6,15,16,18,104–109]; however, we found no other study that inclusively addressed yoga for musculoskeletal pain and QOL in CIPN. We demonstrated the feasibility and safety of a SYM intervention for CIPN with successful inclusion and representation of a minority population using strategies recommended from the literature and ensuring trust and community connection underpinning enrollment. This somatically based yoga appears to improve flexibility and balance, with perceived improvements in various functional activities of daily living. Furthermore, participants reported improved QOL and health literacy, decreased fear of falls, and increased activity levels with incorporation of self-selected aspects of the protocol into their daily lives. Gentle yoga, with variations offered to meet the physical abilities of each participant, was well-tolerated, and no adverse events occurred.

Limitations

There are several limitations of the study. This single-arm pilot study aimed at establishing feasibility and preliminary effects with recruitment, enrollment, and retention of an inclusive SYM protocol. The lack of a control group negates the ability to exclude that findings were due to placebo effect or regression to the mean. The addition of an outcome measure assessing readiness for change may also reveal

self-selection bias. We did not measure long-term follow-up data after the intervention was completed to determine the sustainability of the structured sessions and home yoga-based program. This information on efficacy would be important for future studies.

Although our participants self-identified as representative of Black/African-American and Caucasian ethnicities, we were not successful in recruiting and representing other ethnicities and cultures, such as Asian, Pacific Islander, Hispanic, or other groups present in our local area. This type of early-phase trial offers an important opportunity to test recruitment, enrollment, and retention strategies and to refine the yoga and meditation protocol, as there is a need for increased diversity of minorities, genders, and cancer diagnoses and stages. Only by accomplishing such a step can we appropriately design and power a randomized controlled study of yoga and meditation for pain management and measurement of functional outcomes for all individuals with CIPN.

In summary, we have conducted a mixed methods feasibility trial of SYM to treat CIPN and associated effects on function and QOL with a strong focus on inclusion of a minority population in an urban environment. Future research recommendations include concerted efforts to control for self-selection in yoga studies. Inquiry and understanding of both negative and positive perceptions of yoga, particularly with cancer survivors in an urban center, are key. Few mind-body intervention studies have been performed to address this clinical problem in minority populations, and we believe our effort is an important first step in demonstrating the feasibility of evaluation of inclusive SYM for CIPN. Future randomized controlled trials are needed to establish the comparative efficacy of SYM to address CIPN function and QOL, which affect cancer survivors long after treatment ceases.

Conclusions

Cancer survivors of all ethnic identities with CIPN have chronic pain that activates sensory and motor deficits, leading to inappropriate proprioceptive feedback, impaired postural control, and fall risk in addition to impaired sleep and QOL. To our knowledge, this is the first report to inclusively address SYM for this population. This pilot study, featuring gentle somatically based yoga and meditation, shows feasibility and preliminary evidence on improving functional measures of flexibility, balance, and QOL. Comorbidities and chronic pain add to the complexity of CIPN and require adaptation of postures and use of props for successful outcomes. Accommodating cultural preferences is essential for adherence to classes and home-based continuance of SYM. A randomized clinical trial is needed to confirm these results, with comprehensive minority inclusion and representation.

Conflict-of-Interest Statement

The authors confirm that they have no conflicts of interest to declare.

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