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Yoga education program for older women diagnosed with sarcopenia: A multicity 10-year follow-up experiment

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ABSTRACT

This article reports a multicity yoga education program (YEP) experiment aimed at improving gait speed, muscular strength, and functional performance in Asian and African older women diagnosed with sarcopenia. Posttest gait speed and muscle strength scale scores were higher, and the six functional performance tests scores were above average for women who were from Asian cities; middle class; currently married; living with spouse, children, or kin; with good self-rated health; who regularly attended the YEP lessons and regularly self-practiced. Instructors' self-practice record was the strongest predictor of higher posttest scores. The YEP is an effective long-term prevention for sarcopenic older women.

KEYWORDS

Functional performance; gait speed; muscular strength; older adult women; sarcopenia; yoga; yoga education program

Introduction

Skeletal muscle mass decline occurring with aging is known as sarcopenia. Sarcopenia is prevalent more in older women than older men (Patel et al., 2012), is a component of the fragility syndrome, and indicates a significant health issue related to the progressive decline of muscle tissue quality and strength (Musumeci, 2017). Sarcopenia can be thought of as a muscular analogue of osteoporosis, which is loss of bone, also caused by inactivity and counteracted by exercise. The combination of osteoporosis and sarcopenia results in the significant frailty often seen in the elderly female population. Some of the core symptoms of sarcopenia in aging women are the impact on gait speed, muscle mass, and strength and diminished functional performance (Brioché, Pagano, Py, & Chopard, 2016; Brown, 2015). Exercise, medication, and protein-rich nutrition are the treatment options (Robinson et al., 2017). Exercise is effectively considered as a fundamental point in the treatment of this pathological form of muscle mass reduction (Phillips, 2015). Research has suggested that exercise is effective in slowing down, interrupting, and even inverting the degradation associated with sarcopenia (Makanae & Fujita, 2015). The impact of exercise is usually a superior skeletal muscle

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capacity and the ability to synthesize proteins. Different types of exercise regimens have been suggested, ranging from short- and long-term resistance exercises and intensity training (e.g., Nicastro, Zanchi, Da Luz, & Lancha, 2011). Physical exercise causes an increase in oxidative stress, and at the same time it stimulates the adaptive response of the body against it (Musumeci, Trovato, Imbesi, & Castrogiovanni, 2014).

Apart from cultural and community-based differences in older women's muscle strength, body composition, resistance training response, and fitness status (e.g., Barbosa-Silva et al., 2015; Coin et al., 2013), certain other critical biographical and demographic factors intervene in determining exercise impact. The young-old are likely to be more inclined to pursue an exercise regimen to prevent muscle atrophy (e.g., Hossein-Nezhad & Holick, 2012; Waters, Ward, & Villareal, 2013). Generally, it is also perceived that the optimal timing of intervention to prevent muscular atrophy associated with sarcopenia is at the early onset stage, which is usually postmenopause for women and usually diagnosed in the young-old ages of 60–65 years (Sayer, Syddall, Gilbody, Dennison, & Cooper, 2004). Education levels contribute to health prevention awareness and exercise proclivities (e.g., Aribisala et al., 2013; Elbaz et al., 2013). Specifically for the elderly population, some critical biographical markers such as marital status and living arrangements affect their persistence in following an exercise regimen. Studies have found that single elderly women, or those experiencing a marital disruption, and living alone or in unconventional family arrangements are more likely to avoid or be irregular in physical activities and long-term preventive health care (e.g., Gothe & McAuley, 2016; Kuh et al., 2005). Moreover, perceived and self-rated general health status and the presence or absence of comorbid conditions are compounding factors in determining older adults' exercise, physical activity, and fitness maintenance preferences (e.g., Bauer et al., 2013; Zech et al., 2012).

Yoga is a specific form of physical activity and exercise that has been associated with whole-body protein utilization, body composition, and functional measures in older women. The recent study by Colletto and Rodriguez (2018) indicated that routine yoga practice influenced whole-body protein utilization in older women, which provides a basis for evaluation of long-term benefits of yoga as an alternative mode of exercise for maintaining muscle mass and supporting active aging.

Yoga is an ancient Indian technique of physical and mental discipline generally attributed to a group of scholars known by the name Patanjali. Traditional yoga is qualified by an eightfold path comprising the following: ethical relationships, discipline, physical postures and movements, breathwork and breath control, sense perception and control, mindfulness practice, meditation, and transcendental state (Emerson & Hooper, 2011; McCoy, 2006). One of the key distinguishing feature of this technique is that it is

noncompetitive and focuses on the individual, and its efficacy is contingent on the individual's self-engagement with the technique and prescribed procedures (e.g., Horovitz & Elgelid, 2015).

Few studies have investigated the impact of yoga for aging women's health, disease prevention, and wellness (e.g., Balk, Gluck, Bernardo, & Catov, 2009; Kim, Bembem, & Bembem, 2012; Kim, Bembem, Knehas, & Bembem, 2015; Schmid, Van Puymbroeck, & Koceja, 2010; Sierpowska, Ciechanowicz, & Wasilewska, 2006). To further illustrate, Sierpowska et al. (2006) assessed functional fitness among women aged 60+ participating in yoga or swimming exercises. Balk et al. (2009) examined bone turnover marker responses of sedentary osteopenic postmenopausal women to 12 weeks of one-hour-per-week Hatha yoga classes in addition to home yoga practice. They reported a trend for a moderate positive correlation between total minutes of yoga practice and percent change in bone alkaline phosphatase. Kim et al. (2012) examined the effect of an eight-month yoga intervention on arterial compliance and muscle strength in premenopausal women. Similarly, Kim et al.'s (2015) randomized controlled trial was to examine the effects of a progressive eight-month Ashtanga-based yoga program on bone turnover markers, areal bone mineral density, and volumetric bone characteristics in premenopausal women. Schmid et al. (2010) examined the effect of a 12-week yoga intervention on the fear of falling among older adult women.

The effect of yoga on preventing muscular atrophy due to sarcopenia and improving gait balance, muscle strength, and functional performance needs to be examined from a long-term perspective. This article reports a 10-year follow-up multicity experiment with older women diagnosed with sarcopenia and examined the effect of a customized yoga education program. The study sample comprised 788 older women from eight Asian and African cities at phase 1 and 703 older women from the same cohort, 10 years later, at phase 2.

Based on the literature, the present study has the following hypotheses:

H1: *YEP would be effective for improving gait speed, muscular strength, and functional performance in treatment group older women diagnosed with sarcopenia.*

H2: *The extent of impact of the YEP would vary based on biographical and demographic predictor variables such as city, age, education, occupation, marital status, living arrangement, self-rated health, and comorbid conditions as well as mediator variables such as YEP lessons attended and self-practice.*

H3: *Self-practice would be the strongest predictor of YEP effectiveness in improving function among older women diagnosed with sarcopenia.*

Method

Treatment and control group profile

Table 1 depicts the profile of the treatment and control group older women at both the study phases.

Treatment and control group recruitment

Treatment and control group recruitment was done in stages. At the first stage, occupational therapists practicing at the eight Asian and African cities were contacted through mutual networks. The eight occupational therapists based in each of the eight cities were nodal persons for the study. Occupational therapists provided patient lists (women aged 60 and above) diagnosed with sarcopenia who enrolled at their clinics regularly in the years 2005–2006. Sarcopenia screening was done through three standard indicators—low muscle mass (e.g., > 2 standard deviations below that mean measured in older adults of the same sex and ethnic background), low gait speed (e.g., a walking speed below 0.8 m/s in the 4-min. walking test), and low muscular strength (e.g., grip strength: < 20 kg). Across eight clinics, at phase 1, a list of 1,683 older women sarcopenic patients was obtained. Through the occupational therapists, they were contacted initially by e-mail to gain their consent to participate in the yoga education program experiment and study. A total of 1,576 older women agreed to participate at phase 1. Randomization was done by the researcher through the use of computer-generated random number tables wherein 788 women in phase 1 were allocated to the treatment group and an equal number to the control group. The experiment conditions were unmasked from the treatment and control group women. Control group women did routine exercises and walking as prescribed.

At phase 2, in the year 2016, a total of 703 treatment group women across eight cities remained with the study. Participation attrition was due to various reasons (family emergency = 18, no longer interested = 11, health concerns and sickness = 28, death = 20, travelling = 5, relocation/immigration = 4). An equal number of control group members who were initially a part of the study design but did not participate in the yoga program were contacted. Hence at phase 2, data of 703 older women in the treatment and control groups respectively were analyzed. Figure 1 illustrates the said details.

Consent and ethics

Informed consent was sought from all the treatment and control group older women. There is no registered funder to report for this submission. The study abides by norms of research ethics, has the approval of the independent ethics committee of the University of Mumbai, India, and conforms to the

Table 1. Treatment and control group profiles at phases 1 and 2.

	Phase 1				Phase 2			
	Control group		Treatment group		Control group		Treatment group	
	N	%/M (SD)	N	%/M (SD)	N	%/M (SD)	N	%/M (SD)
City								
Mumbai	114	14.47	114	14.47	104	14.79	104	14.79
Colombo	105	13.32	105	13.32	93	13.23	93	13.23
Kuala Lumpur	112	14.21	112	14.21	91	12.94	91	12.94
Singapore city	109	13.83	109	13.83	97	13.80	97	13.80
Pretoria	86	10.91	86	10.91	81	11.52	81	11.52
Abuja	103	13.07	103	13.07	95	13.51	95	13.51
Nigeria	81	10.28	81	10.28	72	10.24	72	10.24
Harare	78	9.90	78	9.90	70	9.96	70	9.96
Age		63.29 (4.01)		64.01 (3.86)		72.33 (3.76)		73.21 (2.98)
Religion								
Christian	374	47.46	368	46.70	318	45.23	333	47.37
Hindu	219	27.79	225	28.55	201	28.59	198	28.16
Muslim	93	11.80	91	11.55	89	12.66	81	11.52
Buddhist	102	12.94	104	13.20	95	13.51	91	12.94
Class								
Middle class	654	82.99	661	83.88	602	85.63	599	85.21
Upper class	134	17.00	127	16.12	101	14.37	104	14.79
Education								
Up to high school	91	11.55	86	10.91	71	10.10	68	9.67
Bachelor's degree	509	64.59	513	65.10	488	69.42	502	71.41
Higher qualifications	188	23.85	189	23.98	144	26.51	133	18.92
Occupation								
Paid service	141	17.89	119	15.10	112	15.93	109	15.50
Self-employed	93	11.80	102	12.94	85	12.09	91	12.94
Retired	166	21.06	188	23.85	119	16.93	117	16.64
Homemaker	388	49.24	379	48.09	387	55.05	386	54.91
Marital status								
Currently married	398	50.51	412	52.28	305	43.38	348	49.50
Never married	103	13.07	103	13.07	112	15.93	112	15.93
Widowed	217	27.54	211	26.77	209	29.73	203	28.88
Divorced	70	8.88	62	7.87	77	10.95	48	6.83
Living arrangement								
Living alone	299	37.94	286	36.29	276	39.26	266	37.84
With spouse	204	25.89	201	25.51	182	25.89	189	26.88
With spouse and children	155	19.67	168	21.32	164	23.33	155	22.05
With children and/or kin	130	16.50	133	16.88	81	11.52	93	13.23
Self-rated health								
Poor	101	12.82	109	13.83	92	13.09	45	6.40
Fair	589	74.75	608	77.15	585	83.21	286	40.68
Good	98	12.44	71	9.01	26	3.70	259	36.84
Very good	0	0.00	0	0.00	0	0.00	113	16.07
Comorbid conditions								
Osteoporosis	582	73.86	576	73.09	497	70.69	405	57.61
Lifestyle diseases	206	26.14	212	26.90	206	29.30	157	22.33
None	0	0.00	0	0.00	0	0.00	141	20.06
Yoga education program (YEP) lessons attended								481 (38.92)
Self-practice (diary record)								404 (77.21)
Self-practice (instructor)								398 (81.09)
Total	788	100.00	788	100.00	703	100.00	703	100.00

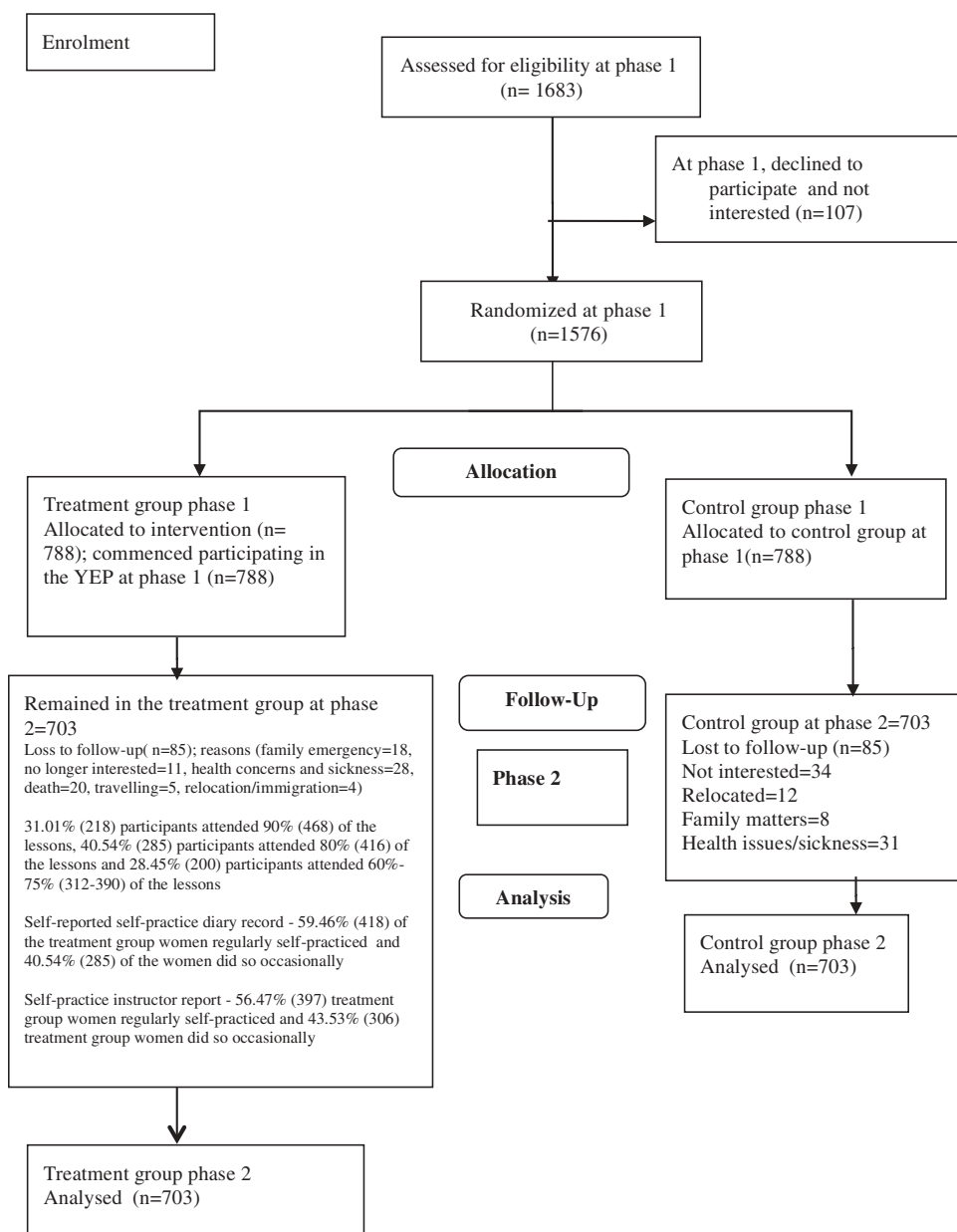


Figure 1. Flow of participants through each stage of the experiment.

norms prescribed in the Declaration of Helsinki, 1975, as revised in 2000. Certified experts from the Yoga Training Institute, Mumbai, India, vetted the yoga education program.

Measures

Pre- and posttest data were collected through an interview comprising questions on biographical and demographic details of the treatment and control group. Details on city, age, religion, class, education, occupation, marital status, living arrangement, self-rated health, and comorbid conditions were sought. Details of YEP lessons attended and self-practice diary and instructor reports were sought at the posttest phase for the treatment group older women.

Three scales were used to measure the outcomes: Dynamic Gait Index, Manual Muscle Test, and Senior Fitness Test. English versions of the schedule and scales were used.

The Dynamic Gait Index (DGI), the original eight-item version developed by Shumway-Cook and Woollacott (1995), was designed to test eight facets of gait to assess the likelihood of falling in older adults. Scoring is on a 4-point ordinal scale ranging from 0 (the lowest level of function) to 3 (the highest level of function). The score range is 0–24, with a score less than 19 predictive of gait imbalance and falls risk among the elderly. Studies have validated the DGI in different contexts (e.g., Asia, Arabia, Europe, and America) and with a cross-section of population groups (e.g., with Arabic, Asian, European, and American elderly) and concluded acceptable psychometric properties including internal and external construct validity, reliability, and convergent validity (e.g., Alghwiri, 2014; Forsberg, Andreasson, & Nilsagård, 2013; Jonsdottir & Cattaneo, 2007). For the present study: Cronbach α = .89; item-scale intercorrelation = .86, and Pearson's r = .88.

The Manual Muscle Test (MMT) originally developed by Lovett and described by Wright in 1912 (Wright, 1912) to assess patients with neuromuscular deficits has been revised, advanced, and promoted, thereby resulting in several methods from which to choose. For this study, the MMT8 developed by Kendall, McCreary, and Provance (1993) was used where eight muscle groups were unilaterally tested in four positions. Scoring is from 0 to 80 for unilateral testing (right side) and 0 to 150 for bilateral testing (both right and left sides for proximal and distal muscles; only unilateral for axial muscles or neck flexors). For the present study, unilateral MMT8 testing was used, with higher scores indicating greater muscle strength. Studies have validated the MMT8 unilateral testing in different cultural contexts (e.g., American, Canadian, Asian, and African contexts) and with a cross-section of population groups (e.g., healthy, community-dwelling and illness-affected elders) and found acceptable psychometric properties including internal and external construct validity, reliability, and convergent validity (e.g., Cuthbert & Goodheart, 2007; Mijndarends et al., 2013; Rider et al., 2010). For the present study: Cronbach α = .89, item-scale intercorrelation = .91, and Pearson's r = .92.

The Senior Fitness Test (SFT) was developed by Rikli and Jones (2001) to evaluate physical function in elderly people and is also used for people with dementia. It comprises six functional tests of strength, endurance, balance, agility, and flexibility. Each test is scored separately on different scales, and the scores are not tallied into an overall score. Normative standards of performance or scores based on gender and age groups have been determined for seniors aged 60–94 (Jones & Rikli, 2002). The whole test takes 30–40 minutes to perform. Normal score ranges from the middle 50% of the population on each of the functional tests are available. Scores above the normal range are considered above average and below are considered below average. Previously published studies have validated the SFT in different cultural contexts (such as with Norwegian, Polish, Danish, and American samples of elderly people) and concluded acceptable psychometric properties including internal and external construct validity, reliability, and convergent validity (e.g., Hesseberg, Bentzen, & Bergland, 2015; Langhammer & Stanghelle, 2011; Purath, Buchholz, & Kark, 2009; Wilkin & Haddock, 2010).

For the present study, functional test-wise reliability-validity measures are as follows: Chair Stand Test [Cronbach $\alpha = .91$; item-scale intercorrelation = .88; Pearson's $r = .91$]; Biceps Curl Test [Cronbach $\alpha = .92$; item-scale intercorrelation = .86; Pearson's $r = .89$]; Chair Sit and Reach Test [Cronbach $\alpha = .93$; item-scale intercorrelation = .89; Pearson's $r = .88$]; 6-minute Walk Test [Cronbach $\alpha = .87$; item-scale intercorrelation = .86; Pearson's $r = .93$]; Back Scratch Test [Cronbach $\alpha = .89$; item-scale intercorrelation = .91; Pearson's $r = .92$]; and 2.45-minute Up-and-Go Test [Cronbach $\alpha = .88$; item-scale intercorrelation = .91; Pearson's $r = .92$].

The interviews were administered in the English language, and the total time required was 60–70 minutes per participant.

Yoga education program (YEP) details

YEP development

The YEP was developed through four meetings of five yoga experts associated with two yoga training institutes. These yoga institutes also had branches or subcenters in other countries and an experience in developing specialized programs. The purpose of the round table meetings (held in the last quarter of the year 2004) was to develop a customized yoga education program for older women diagnosed with sarcopenia. Moreover, the effort was to develop a YEP that combined tenets of different yoga schools and traditions so as to enhance its application in different cultures. The deliberations were recorded, and subsequently the YEP was finalized and vetted by the experts. To implement the YEP, experts recommended yoga instructors based in the eight cities chosen for the study. A master class was organized to

train the instructors on this customized program. The Google group was then formed as a platform to share and provide refresher inputs.

YEP details

The YEP was conceptualized as a package of 40-minute lessons delivered once a week for 10 years in the respective cities. The key features of the YEP designed for women diagnosed with sarcopenia were: (a) postures interspersed with relaxation; (b) slow movements; (c) continuity; (d) inner watchful awareness; (e) feeling of changes in breathing, heart beat, blood flow, and the resonance of sound; and (f) recognition of linear, surface, three-dimensional, and all-pervasive awareness.

The repertoire of one 40-minute lesson was as follows:

- (1) Prayer or simple silence (3 minutes),
- (2) Instant Relaxation Technique (IRT) in supine position with isometric contraction of the muscles (3 minutes),
- (3) Tree posture (i.e., standing still) and centering in tree posture (3 minutes),
- (4) Half-wheel posture with one arm raised and body tilted to the other side and centering therein and repeating the same with the other arm (3 minutes),
- (5) Forward bending posture and backward bending posture (3 minutes),
- (6) Yoga posture—Sun Salutation posture or *Surya Namaskara* (10 minutes),
- (7) Two other yoga postures from the selection of 10 yoga postures for older women (10 minutes),
- (8) Deep relaxation technique (DRT) in supine position (5 minutes).

The different yoga postures that were identified based on moderate difficulty levels for the treatment cohort were as follows: (a) lotus posture or *padmaasana*, (b) diamond posture or *vajrasana*, (c) wheel posture or *chakrasana*, (d) bow posture or *dhanurasana*, (e) salutation pose or *anjanayasana*, (f) half-moon pose or *ardhachandrasana*, (g) half-spinal twist pose or *ardha matsyendrasana*, (h) eagle pose or *garudasana*, (i) cow-face pose or *gomukhasana*, and (j) plough pose or *halasana*. Any two were done in a single lesson, and all were covered in a rotational manner.

Routine instructions were given to conduct the sessions. The apparatus included a yoga mat and loose and comfortable clothing. At the end of each lesson, self-practice was emphasized. The idea behind the customized YEP was that participants move at their own pace, following their breath. This means that when participants are physically ready to handle learning a new posture, the teacher explains the skill behind it and then it becomes a part of the participants' practice.

Self-practice was recorded in two ways. Treatment group women were asked to maintain a self-practice diary where they checked whether the weekly self-practice was done. This diary was submitted each year to the instructors. Further, instructors also maintained a weekly checklist of self-practice based on participant interaction in the next lesson.

Yoga instructors. Sixteen yoga instructors based in the eight cities (two per city) were invited on the recommendation of experts. The yoga instructors delivered the YEP with batches of older women. A reserve group of additional 16 instructors was also maintained (two per city) periodically for additional training support. The profile of the 32 yoga instructors (core and reserve support) was as follows: age phases 1 and 2 ($M = 38.94$ [46.78], $SD = 6.82$ [7.01]), gender (women = 30, men = 2), education (25 = postgraduates, 7 = graduates), occupation (6 = paid service/employment and part-time yoga instructors, 26 = homemakers and full-time yoga instructors), religion (16 = Hindus, 4 = Christians, 12 = Buddhists), and class (18 = middle class, 14 = upper class). All the yoga instructors had undergone the basic, advanced, and training-of-instructors' courses of the respective institutes. The experts, through the master classes, did training for this particular customized YEP, and subsequent refresher inputs were provided through the Google group. Instructors conducted the lessons with groups of older women (Mean group size = 42.56, $SD = 3.04$) once a week from 2006 to 2016.

Procedure. The YEP was delivered by yoga instructors in a designated location in each of the eight cities, proximate to the occupational therapists' clinics. Older women participants in their 60s were enrolled in 2006, and they attended the classes once a week for the study period. Yoga mats, belts, and blocks were used to perform the yoga postures as needed by participants with varying functional capacities. Student investigators attached to the occupational therapists' clinics in each of the cities, at the beginning phase, collected pretest data. Posttest data were collected at phase 2. Under the supervision of the occupational therapists, student investigators collected the data in two months at both the phases. Data were subsequently transferred to the mainframe of the researcher for the analyses. The occupational therapists, yoga instructors, and experts offered their services on a voluntary basis. Student investigators at both the phases were given Amazon gift vouchers.

Statistical methods

The pre- and posttest scores of the treatment and control group older women on the DGI, MMT8, and the six functional tests within SFT were analyzed through one-factor ANOVA. Post hoc analyses using Scheffé's post hoc criteria for significance were used to determine the effects of independent predictors and moderators on the dependent outcomes. Pre- and posttest outcome measure scores of the treatment and control group older women

were compared using *t*-tests. To estimate the theoretical and practical relevance of the results of YEP on older women, the effect size (Cohen's *d*) for the *t*-tests were calculated. Posttest scores of the treatment group were analyzed further through MANOVA where significant effects were examined through nonparametric testing (Kruskal-Wallis). Bonferroni adjusted-alpha levels were used to examine the independent, pairwise, and combined effects of independent and mediator variables on the dependent outcomes. Two five-step hierarchical regression models were developed to determine the most significant predictor variable of the posttest DGI and MMT8 scores of the treatment group. A structural equation model using the maximum likelihood method was developed to analyze the predictors and their mutual covariance impacting the posttest SFT scores of the treatment group on the six functional tests.

Results

Primary analyses comprise 788 older women in the treatment and control groups respectively at phase 1 and 703 women from the respective cohorts at phase 2. The YEP was delivered as intended in terms of lessons held once a week for 10 years in the respective cities. Of the 703 older women who responded at phase 2, 31.01% (218) participants attended 90% (468) of the lessons, 40.54% (285) participants attended 80% (416) of the lessons, and 28.45% (200) participants attended 60%–75% (312–390) of the lessons. The self-reported self-practice diary record showed that 59.46% (418) of the treatment group women regularly self-practiced (i.e., did so at least 75% of the times), and 40.54% (285) of the women did so occasionally. The self-practice instructor report showed that 56.47% (397) treatment group women regularly self-practiced, and 43.53% (306) treatment group women did so occasionally.

The intent-to-treat analyses present the pre- and posttest scores of the treatment and control group women on the specified outcome measures. The significant predictor and mediator variables of the posttest scores of the treatment group women were analyzed through hierarchical regression and multilevel structural equation modelling.

DGI, MMT8, and SFT scores

Control group pretest

The average pretest DGI score for the control group women was 16.43 (*SD* = 3.78). The average pretest MMT8 score for the control group women was 41.28 (*SD* = 6.73). On the six functional tests within SFT, 32.21% of the control group senior women had above-average scores, and 67.79% of the control group women had below-average scores on the six functional tests within SFT.

The effects of class, marital status, and living arrangements were significant ($p < .05$). Post hoc analyses using Scheffé's post hoc criterion for significance indicated that the pretest DGI and MMT8 scores were lower and scores on the six functional tests within SFT were below average for control group older women in the upper class, single (i.e., never married, widowed, and divorced) and those who lived alone.

Control group posttest

The average posttest DGI score of the control group women was 17.28 ($SD = 2.87$). The average posttest MMT8 score for the control group women was 42.03 ($SD = 5.98$). On the six functional tests within SFT, 33.98% of the control group senior women had above-average scores, and 66.02% of the control group women had below-average scores on the six functional tests within SFT.

The effects of marital status, living arrangement, self-rated health, and comorbid conditions were significant ($p < .05$). Post hoc analyses using Scheffé's post hoc criterion for significance indicated that the posttest DGI and MMT8 scores were lower and scores on the six functional tests within SFT were below average for single women (i.e., never married, widowed, divorced), who lived alone, with poor self-rated health and with osteoporosis as a comorbid condition.

Treatment group pretest

The average pretest DGI score for the treatment group women was 15.88 ($SD = 3.78$). The average pretest MMT8 score for the control group women was 42.51 ($SD = 5.89$). On the six functional tests within SFT, 34.56% of the control group senior women had above-average pretest scores, and 65.44% of the control group women had below-average scores on the six functional tests within SFT.

The effects of class, living arrangements, and self-rated health were significant ($p < .05$). Post hoc analyses using Scheffé's post hoc criterion for significance indicated that the pretest DGI and MMT8 scores were lower and scores on the six functional tests within SFT were below average for treatment group older women in the upper class, living alone, and with poor self-rated health.

Treatment group posttest

The average posttest DGI score of the treatment group women was 22.39 ($SD = 2.43$). The average posttest MMT8 score of the treatment group women was 68.39 ($SD = 6.52$). On the six functional tests within SFT, 76.29% of the treatment group senior women had above-average posttest scores, and 23.71% of the treatment group women had below-average posttest scores on the six functional tests within SFT.

The effects of city, class, marital status, living arrangements, self-rated health, YEP lessons attended, self-practice self-diary record, and self-practice instructor record were significant ($p < .05$). Post hoc analyses using Scheffé's post hoc criterion for significance indicated that the posttest DGI and MMT8 scores were higher, and scores on the six functional tests within SFT were above average for treatment group older women from Asian cities who were middle class; currently married; living with spouse, children, or kin; with fair and good self-rated health who attended more than 75% of the YEP lessons and regularly self-practiced as per their own diary records and instructor records.

Effect of YEP on DGI, MMT8, and SFT scores

Table 2 depicts the pre- and posttest scores on DGI, MMT8, and SFT of the control and treatment group older women. The scores of the control and treatment group were equal at baseline. There was no significant difference in the pre- and posttest scores of the control group women. Treatment group women's posttest DGI and MMT8 scores were higher, and SFT functional test scores were above average than their own pretest scores as well as the pre- and posttest scores of the control group.

Effects of sociodemographic predictors and program-related mediators on posttest scores

The posttest scores of the treatment group women on the DGI, MMT8, and six functional tests within SFT were further subject to a MANOVA with eight predictor and mediator variables: city, class, marital status, living arrangements, self-rated health, YEP lessons attended, self-practice self-diary record, and self-practice instructor record. Significant associations were further examined through nonparametric testing (Kruskal-Wallis). All predictor and mediator variables independently affected the outcome measures. The combined effects of the marital status, living arrangements, and self-rated health and YEP lessons attended, self-practice diary record, and self-practice instructor record respectively were significant ($p < .05$). Tests were further conducted using Bonferroni's adjusted alpha levels at .00625 (.05/8) per test. The independent and pairwise effects of significant predictor and mediator variables continued to be significant ($p < .01$). DGI and MMT8 scores were higher, and scores on the six functional tests of SFT were above average under the combined effects of significant predictor and mediators (older women from Asian cities who were middle class; currently married; living with spouse, children, or kin; with fair and good self-rated health, who attended more than 75% of the YEP lessons and regularly self-practiced as

Table 2. Pre- and posttest dynamic gait index (DGI), manual muscle test-8 (MMT8), and senior fitness test (SFT) scores.

	Control group						Treatment group						Control and treatment group						Control group pre and posttest**						Treatment group pre- and posttest**					
	Pre-test			Posttest			Pretest			Posttest			treatment group pretest#			Control group and posttest#			treatment group posttest*			treatment group pre- and posttest**								
	M	SD		M	SD		M	SD		M	SD		t	p*	D	t	p*	d	t	p**	d	t	p**	d						
DGI	16.43	3.78		17.28	2.87		15.88	3.78		22.39	2.43		79.23	.21	.18	88.91	.23	.19	62.39	.01	.43	59.88	.00	.48						
MMT8	41.28	6.73		42.03	5.98		42.51	5.89		68.39	6.52		88.92	.17	.14	56.23	.18	.14	48.99	.02	.38	43.88	.01	.47						
SFT average																														
Chair stand (no. of stands)	14.17	1.23		13.98	1.65		14.03	1.73		20.89	2.37		92.29	.19	.12	89.23	.18	.18	56.98	.00	.41	51.38	.02	.48						
Arm curl (no. of reps)	15.88	2.87		16.45	3.12		15.83	2.47		20.88	3.01		12.31	.16	.12	18.92	.21	.14	9.82	.01	.43	10.82	.02	.52						
6-min. walk (no. of yards)	547.26	48.75		576.79	50.25		572.67	61.05		682.28	79.21		198.11	.23	.12	188.23	.34	.15	82.39	.02	.41	68.32	.02	.48						
2-min. step (no. of steps)	88.61	10.93		88.40	10.9		87.91	10.32		110.21	12.39		34.89	.13	.14	56.78	.41	.16	38.98	.04	.51	41.29	.03	.51						
Chair sit-and-reach (inches ±)	2.8	.43		2.75	.41		2.79	.46		6.03	1.11		18.93	.11	.18	23.45	.61	.18	19.87	.03	.49	18.32	.01	.48						
Back scratch (inches +/-)	.21	.43		-1.29	.37		-1.29	.32		1.8	.18		29.33	.12	.14	38.97	.12	.17	29.88	.02	.38	22.38	.02	.51						
8-ft-up-and-go (seconds)	5.69	.40		5.35	.41		6.31	.56		3.86	.29		34.09	.13	.12	45.22	.17	.16	33.87	.01	.41	18.07	.00	.52						

#df = 787; ##df = 1489; *df = 1489; *p < .05; **df = 1489; *p < .01; Data source: pre- and posttest DGI, MMT8, and SFT scores of control and treatment group women.

Table 3. Significant multivariate effects on the posttest DGI, MMT-8, and SFT scores.

Variable(s)	Pillai's trace	F	df	Error df
City	.109	89.21	7	695
Class	.113	71.29	1	695
Marital status	.203	73.22	3	695
Living arrangements	.141	68.31	3	695
Self-rated health	.118	56.93	3	695
YEP lessons attended	.128	90.21	1	695
Self-practice diary record	.201	68.92	1	695
Self-practice instructor record	.089	91.03	1	695
Marital status* YEP lessons attended	.104	87.22	3	694
Marital status * self-practice diary record	.097	86.39	3	694
Marital status * self-practice instructor record	.137	78.32	3	694
Living arrangements * YEP lessons attended	.178	102.76	3	694
Living arrangements * self-practice diary record	.146	49.03	3	694
Living arrangements * self-practice instructor record	.118	112.08	3	694
Self-rated health * YEP lessons attended	.125	89.33	3	694
Self-rated health * self-practice diary record	.204	75.39	3	694
Self-rated health * self-practice instructor record	.231	68.93	3	694
City*class* marital status*living arrangements* self-rated health* YEP lessons attended* self-practice diary record* self-practice instructor record	.286	36.88	189	686

$p < .05$

per their own diary records and instructor records). Table 3 depicts the significant multivariate effects on the posttest outcome measure scores.

Tables 4 and 5 depict the five-step hierarchical regression models on the variables predicting the posttest scores of the treatment group older women on the DGI and MMT8. Table 4 indicates that the strongest predictor of the posttest DGI scores of the treatment group was self-practice instructor record, which uniquely explained 17% of the variation. Table 5 also indicates that the strongest predictor of the posttest MMT8 scores of the treatment group was self-practice instructor record, uniquely explaining 18% of the variation. Together all the eight predictors accounted for 81.2% and 76.3% variation in the posttest DGI and MMT8 scores respectively.

Table 6 and Figure 2 depict the structural equation model with standardized coefficients of the treatment group older women's posttest scores on the functional tests within SFT. City, class, marital status, living arrangement, self-rated health, YEP lessons attended, self-practice diary record, and self-practice instructor record were the independent variables. Additionally, posttest scores on DGI and MMT8 were also added as predictors. The maximum likelihood method was used with 11 iterations, and log likelihood = -92.817291. The model confirms that the independent variables and two other predictor variables influenced the scores on the six functional tests of the SFT. Further, the goodness of fit measures were also significant, indicating model reliability. The model further confirmed the covariance between self-rated health and YEP lessons attended, YEP lessons attended

Table 4. Summary of hierarchical regression analysis for variables predicting posttest DGI scores of treatment group women.

Variable		β	t	sr^2	R	R^2	ΔR^2
Step 1					.23	.04	.05
	City	.26	2.13*	.03			
Step 2					.56	.62	.18
	City	.03	.29*	.02			
	Class	.31	2.03**	.15			
	Marital status	.26	1.89**	.04			
Step 3					.64	.72	.22
	City	.04	.22**	.02			
	Class	.43	1.09***	.06			
	Marital status	.34	2.33**	.03			
	Living arrangement	.38	3.01***	.04			
	Self-rated health	.59	2.15**	.03			
Step 4					.68	.76	.19
	City	.04	.38*	.04			
	Class	.28	2.33**	.02			
	Marital status	.09	1.78**	.02			
	Living arrangement	.34	3.34***	.05			
	Self-rated health	.56	2.78***	.01			
	YEP lessons	.51	3.59***	.09			
	Self-practice diary record	.48	4.08***	.09			
Step 5					.72	.84	.17
	City	.08	.72*	.03			
	Class	.19	1.03*	.04			
	Marital status	.18	2.01**	.05			
	Living arrangement	.11	2.13**	.04			
	Self-rated health	.28	3.04**	.05			
	YEP lessons	.31	4.17***	.06			
	Self-practice diary record	.43	5.03**	.00			
	Self-practice instructor record	.56	6.18***	.00			

Note. $N = 703$; * $p < .05$, ** $p < .01$, *** $p < .001$.

and self-practice diary record, YEP lessons attended and self-practice instructor record, self-practice instructor record and DGI scores, self-practice instructor record and MMT8 scores, and DGI and MMT8 scores. This means that those with good self-rated health regularly attended the YEP lessons, regular attendees self-practiced regularly, and those who self-practiced regularly demonstrated better gait balance, lesser falls risk, and better muscle strength posttest. The combination of these dyads of positive predictors and mediators had a confounding positive predictor effect on overall functional fitness of senior women.

Discussion and conclusion

Results of this 10-year follow-up study indicate that YEP could be an effective physical activity to improve functional fitness and performance among sarcopenic older women. The first hypothesis stating that YEP would be effective for improving gait speed, muscular strength, and functional performance in

Table 5. Summary of hierarchical regression analysis for variables predicting posttest MMT8 scores of treatment group women.

Variable	β	t	sr^2	R	R^2	ΔR^2
Step 1				.24	.05	.05
City	.31	1.87*	.02			
Step 2				.58	.64	.16
City	.02	.31*	.04			
Class	.43	1.08**	.06			
Marital status	.31	2.04**	.05			
Step 3				.66	.71	.20
City	.03	.41***	.03			
Class	.51	2.13***	.07			
Marital status	.48	3.04**	.04			
Living arrangement	.56	4.12***	.06			
Self-rated health	.44	3.88**	.02			
Step 4				.72	.68	.17
City	.06	.47*	.05			
Class	.32	3.34**	.04			
Marital status	.18	2.38**	.03			
Living arrangement	.48	4.05***	.06			
Self-rated health	.58	2.88***	.02			
YEP lessons	.61	4.16***	.11			
Self-practice diary record	.52	3.18***	.08			
Step 5				.78	.81	.18
City	.09	.78*	.02			
Class	.18	2.17*	.05			
Marital status	.16	1.74**	.04			
Living arrangement	.12	3.14**	.05			
Self-rated health	.33	4.11**	.06			
YEP lessons	.42	5.06***	.02			
Self-practice diary record	.81	5.68**	.01			
Self-practice instructor record	.76	6.93***	.00			

Note. $N = 703$; * $p < .05$, ** $p < .01$, *** $p < .001$.

treatment group sarcopenic older women is supported. The outcome measures of the treatment and control group women were equal at baseline. At the pretest phase for the control group, DGI and MMT8 scores were lower and the scores on the six functional tests within SFT were below average for upper-class and single women and those who lived alone. At the posttest phase among the control group, scores were lower for single women who lived alone and who had poor self-rated health and osteoporosis as a comorbid condition. Treatment group women's pretest scores were lower for the upper-class older women living alone with poor self-rated health. The t -tests and Cohen's d statistics showed that the YEP was effective for the treatment group women who scored higher posttest on the DGI, MMT8, and all six tests of the SFT. So, akin to randomized trials and short-term follow-up studies on yoga's impact for older women (e.g., Balk et al., 2009; Kim et al., 2012, 2015; Schmid et al., 2010; Sierpowska et al., 2006), results of this long-term follow-up study also indicated a positive impact of yoga for sarcopenic older women.

The second hypothesis proposing that the extent of impact of the YEP would vary based on biographical and demographic predictor variables as

Table 6. SEM of posttest SFT functional tests scores of the treatment group older women (standardized coefficients).

Structural equation standardized		Coeff.	OIM Std. Error	z	P > z	95% confidence interval	
SFT							
	City	2.0182	.0182	3.41	.04	.0921	3.9912
	Class	1.3387	.1138	2.98	.03	.0043	2.0391
	Marital status	1.0928	.1212	3.04	.04	.0123	4.5162
	Living arrangement	.9982	.2118	4.11	.03	-.1203	1.9932
	Self-rated health	2.3091	.2194	5.03	.03	.0312	4.5611
	YEP lessons attended	2.4487	.3019	4.37	.03	1.0091	5.6121
	Self-practice diary record	3.0128	.1883	3.08	.01	1.8121	6.5123
	Self-practice instructor record	4.5561	.4192	2.96	.04	2.0981	7.8823
	DGI scores	4.8902	.1556	1.86	.01	2.3314	7.8123
	MMT8 scores	4.5587	.3091	4.03	.03	2.3388	8.0912
	Constant	5.0087	.3386	3.03	.00	3.0412	6.8823
Mean (city)		2.1092	.4598	3.98	.03	2.3091	7.8832
Mean (class)		3.4412	.5561	2.38	.03	1.8933	7.8823
Mean (marital status)		2.3871	.0102	2.88	.01	.9928	4.0516
Mean (living arrangement)		3.4418	.1123	3.41	.02	-.2284	5.0331
Mean (self-rated health)		3.0812	.1028	1.86	.04	-.3921	4.9983
Mean (YEP lessons attended)		4.0081	.2174	2.09	.02	-.0093	5.3398
Mean (self-practice diary record)		3.4871	.1023	3.44	.02	-.9813	4.5523
Mean (self-practice instructor record)		4.5589	.1129	3.86	.02	1.0923	6.8984
Mean (DGI scores)		5.0198	.2661	2.85	.02	.9934	7.8934
Mean (MMT8 scores)		6.7782	.3012	2.99	.01	2.3383	8.9784
Variance (e. SFT)		3.9987	.1882			1.2982	8.9932
Variance (city)		2.3817	.3128			1.3386	7.8834
Variance (class)		3.8891	.3389			1.8832	7.8091
Variance (marital status)		4.0012	.6672			3.0083	7.9901
Variance (living arrangement)		3.8873	.8912			.8833	9.0033
Variance (self-rated health)		2.9981	.9012			1.4872	3.5679
Variance (YEP lessons attended)		3.4012	.8834			1.3081	5.8923
Variance (self-practice diary record)		3.0088	.2231			1.8843	6.0832
Variance (self-practice instructor record)		4.0091	.2118			.9903	8.0312
Variance (DGI scores)		5.0002	.1182			2.0033	9.1128
Variance (MMT8 scores)		6.7782	.1991			1.9834	8.9974
Covariance (self-rated health, YEP lessons attended)		5.0123	.2238	4.03	.00	1.0321	8.9922
Covariance (YEP lessons, self-practice diary record)		7.8823	.3008	3.22	.01	.8032	8.6634
Covariance (YEP lessons, self-practice instructor record)		8.0023	.4176	2.85	.01	.5564	10.0061
Covariance (self-practice instructor record, DGI scores)		2.0123	.3389	1.98	.00	-.0192	6.5544
Covariance (self-practice instructor, MMT8 scores)		3.4486	.1198	2.39	.00	.0034	5.9982
Covariance (DGI scores, MMT8 scores)		2.8831	.2446	3.31	.00	.0095	4.7893

$\chi^2(45) = 308.92, p < .001$; Goodness-of-fit Index (GFI) = .94; Normed Fit Index (NFI) = .88; Root mean square error of approximation (RMSEA) = .05; OIM = Observed Information Matrix.

well as mediator variables such as YEP lessons attended and self-practice is also supported. Within the treatment cohort, posttest DGI and MMT8 scores were higher and SFT functional tests scores were above average for women from Asian cities who were middle class; currently married; living with spouse, children, or kin; with fair and good self-rated health, who attended more than 75% of the YEP lessons and who regularly self-practiced as per

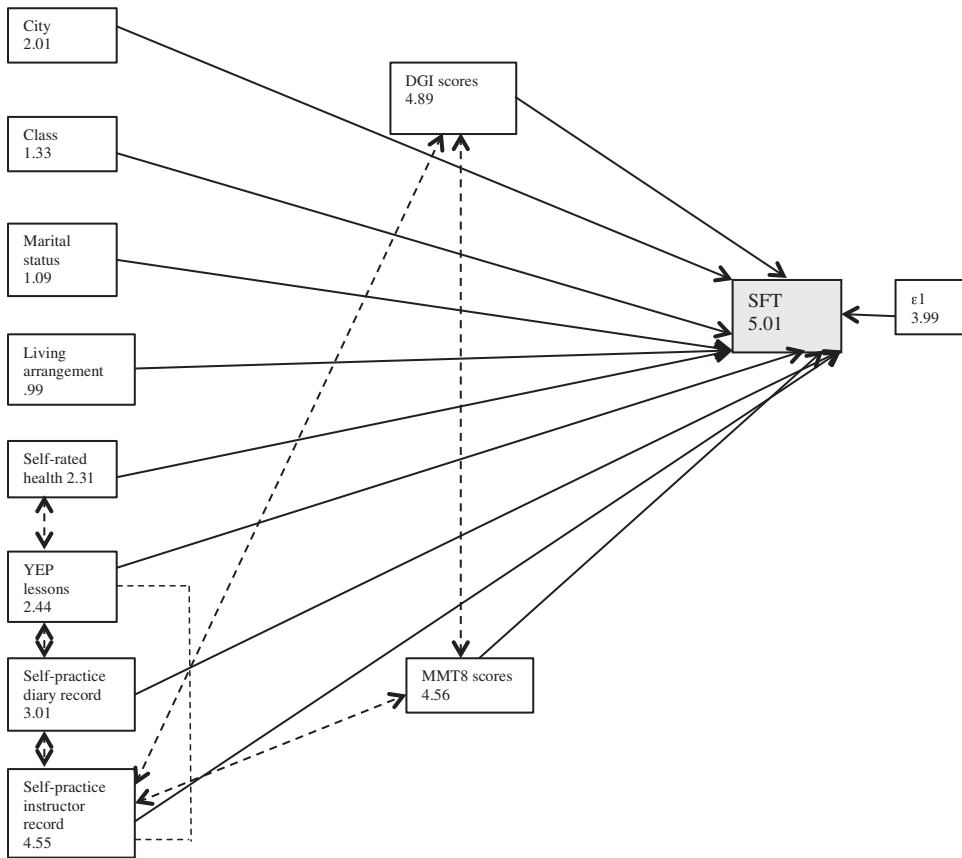


Figure 2. Posttest senior fitness test scores of participants.

their own diary record and instructor records. Multivariate analyses confirmed the independent and combined effects of these independent and mediator variables. Additionally MANOVA indicated that currently married women living with spouse, children, and/or kin who had fair and good self-rated health were more likely to attend more YEP lessons and regularly self-practice. The structural equation model confirmed that the independent predictor variables and program mediators including attendance and regular practice as well as DGI and MMT8 scores influenced the cohort's functional performance.

YEP treatment was more effective for women from Asian cities vis-à-vis their African counterparts. This could be due to greater cultural familiarity with yoga among Asians (e.g., McCoy, 2006). More investigations are required on modifications that would work for older women of other cultures. Older middle-class women remained at an advantage in both the pre- and posttest phases. There is no earlier research that highlights the difference

between middle-class and upper-class sarcopenic older women and their treatment responses. While there is no sufficient explanation, this could be due to the social and personal realities of affluent older women who may not have sufficient stimuli to motivate them to pursue the treatment seriously.

Corroborating earlier literature, results of this study also supported that married women living in standard family arrangements and in good self-rated health responded better to the YEP (e.g., Bauer et al., 2013; Gothe & McAuley, 2016; Kuh et al., 2005; Zech et al., 2012). This suggests that for single older women living alone and in poor health the YEP needs to be modified or intensified. Alternatively, this also suggests that along with treatment addressing sarcopenia symptoms, other wellness interventions to address moods and wellness states may need to be combined.

Results of the hierarchical regression models indicated that instructor's record of regular self-practice was the strongest predictor of posttest increased DGI and MMT8 scores, thereby supporting the third hypothesis. Hence, older women who regularly self-practiced were less likely to be prone to falls and gait imbalance and also have better muscle strength. This, in turn, as depicted in the multilevel structural equation model, contributed to balance and flexibility outcomes as assessed by the Senior Fitness Tests among older adult women. This adds to yoga therapy literature and the technique's unique feature, which proposes that its efficacy rests on clients' personal involvement (e.g., Horovitz & Elgelid, 2015).

Limitations

Data were collected at only two specific phases—pretest or at the beginning of the study period and posttest or at the end of the study period 10 years later. This posttest-only study does not capture the interim changes and the iterative improvement in gait speed, muscle strength, and functional performance. Whereas capturing yearwise changes would have its own distinctive value, the effort in this study was to see the functional improvement in older women recruited in their 60s and subsequently in their 70s. From that perspective, and with a cross-cultural sample, results are generalizable to the extent that they show that sustained and long-term yoga practice has, in general, a positive effect in improving gait balance, muscle strength, and functional performance among sarcopenic women. However, the experimental conditions were unmasked from the participants and control group, which is a limitation that could affect the results as the treatment group women could have been inclined to provide more favorable treatment effect responses, or the control group cohort could have been inclined to demonstrate equivalent functional improvement. A completely masked randomized trial with a smaller sample and across fewer sites is required to overcome this. Further, there are no qualitative data to examine older women's own

perceptions of functional improvement through sustained yoga practice, which provides a direction for further research. The sample of treatment and control groups across cities is diverse, which could mean that nuanced variations or specific differences on treatment effect and responses may not have been adequately captured. Smaller-sample studies with fewer experiment sites may provide a view of embedded differentials. Investigations are also needed to examine the intervening effects of certain other critical variables such as family support, spousal variables, adult children-related variables, and other significant life course events that may impact sarcopenia symptoms and treatment response. Moreover, within the occupation profile of older women, their additional caregiving responsibilities or carework, and whether and how that impacts the disease aetiology and treatment-seeking behavior, preventive health-care behavior, and treatment response is another subject for further investigation.

Practical implications

Results have the following practical implications. This customized YEP could be employed as an effective preventive technique for sarcopenic older women to improve gait speed, muscle strength, and general functional proficiency. There is value in commencing the program in young-old ages so as to prevent muscle atrophy and decline in older ages. Some cultural variations would need to be incorporated for African elderly women, such as familiar spiritual ideology and cultural practices, supplementing the instructions with references to native African belief systems, increasing communication (education, instructor availability, “buddy system,” etc.), and including natives as instructors and participants. Further, the YEP would need to be supplemented with some additional motivational and affect-based interventions for older women from the upper class, single women, and those living alone. Since the technique’s efficacy rests on participants’ personal engagement, strengthening that component and its assessment mechanism should be built into the intervention.

Disclosure statement

No potential conflict of interest was reported by the author.

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