REVIEW

Narrowing the Gap for Minority Cancer Survivors: Exercise Oncology in the Past, Present, and Future

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ABSTRACT

While the field of exercise oncology has substantially progressed in recent years, a significant void exists in the inclusion of and focus on minority patients diagnosed with cancer, particularly blacks and Hispanics. Blacks and Hispanics are less physically active, experience higher rates of comorbid conditions, and have poorer cancer prognosis when compared to white counterparts. Exercise prevents and reduces an array of health conditions, including cardiovascular disease, diabetes, obesity, and risk of certain cancers. However, black and Hispanic cancer survivors are underrepresented across exercise intervention trials. In this review, we discuss previous explorations among minority cancer survivors with a focus on exercise prescription, targeted outcomes, patient demographics, and barriers to exercise. We also discuss knowledge gaps and future directions necessary to progress the field of exercise oncology to include a more diverse cancer survivor cohort. In brief, we found few studies have evaluated the effect of exercise on physiologic health outcomes in black and Hispanic cancer survivors, with much research focused on psychosocial health. A majority of minority population-based research specifically targets the black breast cancer survivor population, with reported exercise-induced improvements observed in weekly physical activity, cardiorespiratory fitness, muscle strength, quality of life, and fatigue. Minority cancer survivors also face unique challenges and barriers to exercise participation despite acknowledgement of the benefits with physical activity. Future investigations warrant explorations of exercise timing across the cancer continuum, inclusion of different types of cancer survivors, and novel exercise strategies with inclusion of culturally tailored educational and behavioral components. *Journal of Clinical Exercise Physiology*. 2020;9(4):155–170.

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INTRODUCTION

While the field of exercise oncology has substantially progressed in recent years with novel exercise approaches, prognostic outcomes, and targeting rare diseases, a significant void exists in the inclusion and focus on minority patients, particularly blacks and Hispanics diagnosed with cancer. Blacks and Hispanics (aka, minorities) are less physically active, experience higher rates of comorbid conditions, and have a poorer cancer prognosis when compared to white counterparts (1–10). To date, blacks have the highest death rate and shortest survival of any racial/ethnic group across most cancers in the US (3). For example, mortality rates for

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black women are 44% higher for colorectal cancer and 39% higher for breast cancer than white women (3). In addition, black adults with colorectal cancer have a less favorable prognosis and present with more advanced-stage disease than white patients (4). Black men and women, when compared to their white counterparts, are also less physically active (34% versus 22%, respectively) (5,6). Of note, Hispanics are disproportionally affected by chronic conditions such as elevated blood pressure, central adiposity, diabetes, and obesity (7). Hispanic men and women report lower levels of physical activity (42% and 41% respectively) when compared to their non-Hispanic white counterparts (52% and 50%) (7). Hispanic women are at higher risk of breast cancer mortality, advanced cancer stage at diagnosis, and poorer breast cancer prognosis when compared to non-Hispanic white women (8). Among Hispanic men, the most commonly diagnosed cancers are prostate (21%) and colorectal (12%) (11), and they are more likely to present with advanced-stage prostate disease when compared to non-Hispanic white men (9) and have a 10% increased risk of prostate cancer specific mortality (10).

Black and Hispanic patients comprise 8% and 6%, respectively, of all patients enrolled in publicly funded National Cancer Institute clinical trials (12). This is problematic as researchers cannot learn enough about the differences among groups to ensure the generalizability of results. Aside from prostate cancer research, blacks and Hispanics participate in cancer clinical trials at much lower rates than whites and Asians (1,2). Few studies have evaluated the effect of exercise on health outcomes in black and Hispanic cancer survivors, with the majority of research to date specific to psychosocial health. A majority of minority population-based research involves the breast cancer population, with reported improvements in weekly physical activity, cardiorespiratory fitness, muscle strength measures, functional movement, total quality of life (QOL), and fatigue occurring in black breast cancer survivors after completion of exercise (13). A detailed breakdown of patient demographics from previous studies is shown in Table 1. Thus, the goal of this review is to discuss exercise interventions among minority cancer survivors with a focus on exercise prescription, targeted outcomes, and barriers to exercise. We will also discuss knowledge gaps and future directions necessary to progress the field of exercise oncology to include minority cancer survivors.

EXERCISE MODALITY (TABLES 2 AND 3)

Aerobic Exercise

Aerobic exercise is a common and often preferred modality because of the well-established impact on reducing the risk of cardiovascular diseases (14–16). Cardiorespiratory fitness declines 5% to 26% during exposure to various cancer treatment regimens, with patients potentially not recovering even after cessation of treatment (17). Cancer survivors are also at increased risk for cardiovascular disease (CVD)-related mortality (18) with CVD-related mortality being reported higher among younger black breast cancer survivors than white breast cancer survivors (13% versus 9%, respectively) (19). Aerobic exercise improves cardiorespiratory fitness (20,21) and CVD risk (21) in cancer survivors.

Among aerobic exercise only interventions, studies including black cancer survivors have primarily focused on improving functional capacity through VO_2 (22) and daily physical activity as measured through step count (23). These outcomes target 2 common modalities, walking or cycling. (22,23). Wilson et al. (2005) executed a supervised design that required only 1 d per week of aerobic exercise for 75 min at an intensity based on the number of steps in black breast cancer survivors (n = 24) and reported a 92% adherence rate (23). Given the study was a pilot feasibility design, patients served as their own controls. Mean steps per day increased significantly from 4,791 to 8,297 from baseline to immediate postintervention (23). Influential factors that may have contributed to this success may be the use of community-based and church-based centers to conduct exercise. Wilson et al. (2005) also included a curriculum describing benefits and barriers to exercise, the relationship between health and cancer risk and exercise, as well as personal assessments and problem-solving sessions for motivation. These could potentially be linked to the 3% improvement in attitude toward exercise measured by the Exercise Decisional Balance instrument (23). On the contrary, Ray et al. (2018) achieved a 96% compliance rate in a supervised cycle-based study of colorectal cancer survivors (n = 7) with a 29% black enrollment. This intervention took place twice weekly and included moderate-to-vigorous intensity exercise with a time obligation that increased from 20 to 25 min to 35 to 45 min in length. However, there were no additional behavioral or cultural components to supplement the intervention (22). In addition, it was reported that 12 weeks of supervised aerobic exercise increased VO_{2peak} by 3.1 $mL \cdot kg^{-1} \cdot min^{-1}$ and significantly improved the physical component score of the Short Form-36 (SF-36) by 7%, although the mental health score for SF-36 and Functional Assessment of Cancer Therapy-Colorectal did not improve (22). This suggests that although physical outcomes may improve with cycling, alternative training or additional approaches may be needed to improve other aspects of psychosocial health in minority cancer survivors.

Hispanics are severely underrepresented in aerobic exercise trials, with no known studies to date having targeted this population. Lee et al. (2018) examined high intensity interval training for patients with breast cancer (n = 30), which included 73% patients who self-identified as Hispanic (24). This study design required 3 d per week of supervised vigorous exercise for 30 min. Lee et al. (2019) reported that while VO_{2peak} was maintained in the exercise training group, VO_{2peak} decreased by 2.6 $mL \cdot kg^{-1} \cdot min^{-1}$ in the control group from baseline to 8 weeks in patients undergoing chemotherapy (24). This supports the role of exercise training in preventing the negative impact of chemotherapy treatment in cardiorespiratory fitness in cancer patients. There were no cultural or behavioral aspects to supplement this study, however the

TABLE 1. Exercise intervention trials for Hispanic and black cancer survivors.

Author, Sample Size, Population	Outcome Variables	Intervention Setting	Intervention FITT	Additional Intervention	Adherence/ Retention	Results[a]
Wilson et al. 2005 (23); 24 black breast cancer survivors	**Steps walked:** Pedometer **Body composition:** BMI; waist, hip and arm circumferences; and body fat percentage by Futrex, blood pressure **Attitudes toward exercise:** Exercise decisional balance instrument **Anxiety:** Cancer anxiety scale	Supervised by instructor and staff Community center or church	**Frequency:** 1x week **Intensity**: Progressive step goals were provided **Time:** 1.25 h **Type:** Walking	**Education:** Sessions were presented by the same instructor and staff, using a curriculum that described benefits and barriers to exercise, its relationship to health and cancer risk, and personal assessment/ problem-solving sessions for motivation. Didactic, interactive, and small-group processes were used during each session	92% retention	**Improvements seen in:** Steps per day from baseline to postintervention from 4,791 to 8,297 ($P < 0.001$), hip circumference ($P = 0.009$), forearm circumference ($P < 0.001$), systolic blood pressure ($P = 0.002$), diastolic blood pressure ($P = 0.001$), and attitude toward exercise ($P = 0.005$) **No improvements seen in:** Anxiety ($P = 0.88$)
Hanson et al. 2013 (26); 17 black prostate cancer patients on androgen deprivation therapy	**Muscular strength:** 1RM for the unilateral knee extension, chest press, and leg press, performed using Keiser air-powered machines **Muscular endurance:** Maximum number of reps of chest and leg press at 70% 1RM **Unilateral power, velocity, and torque:** Keiser A-430 air-powered machine through knee extension **Body composition:** Muscle mass and percent body fat assessed through DXA **MV:** CT **Physical function:** 6-meter walk, timed up and go, chair stands, stair climb, and 400-m walk **Psychosocial:** BFI and the FACT-P questionnaires **Blood biomarkers**: Hemoglobin and PSA	Supervised	**Frequency:** 3x week **Intensity:** 15 reps at 5RM, participants completed first 4–5 reps until they could no longer complete the movement, weight was lowered until they could complete 1–2 additional reps. This was repeated until all 15 reps were completed **Time:** 1 h **Type:** Resistance exercise using Keiser machines; unilateral knee extension, chest press, seated row, seated hamstring curl, abdominal crunch, and leg press	N/A	94.6% ± 1.6% compliance	**Improvements seen in:** 1RM strength for the knee extensors, chest press, and leg press (Ps < 0.001), muscle endurance for chest and leg press (Ps < 0.001), power at both absolute ($P < 0.001$) and relative loads (Ps < 0.01), peak torque at all loads ($P < 0.05$), absolute peak velocity ($P < 0.001$), body mass ($P = 0.023$), total body muscle mass ($P < 0.001$), and muscle mass in the upper body ($P = 0.003$), lower body ($P = 0.001$), and appendicular ($P = 0.001$) regions, thigh MV ($P < 0.001$), percent body fat ($P = 0.012$), chair stands, 6-meter walk test, timed up and go, stair climb, and 400-m walk (Ps < 0.05), fatigue perception ($P = 0.011$), FACT-P ($P = 0.042$), sex hormone-binding globulin ($P = 0.025$) **No improvements seen in:** Subcutaneous or intermuscular fat (P value not reported), hemoglobin ($P = 0.717$), PSA ($P = 0.716$)

TABLE 1. Continued.

Author, Sample Size, Population	Outcome Variables	Intervention Setting	Intervention FITT	Additional Intervention	Adherence/ Retention	Results[a]
Spector et al. 2014 (13); 17 black breast cancer survivors	**Physical activity:** IPAQ and accelerometry **Cardiorespiratory fitness:** Electric braked cycle ergometer **Muscle strength:** Biodex System 3 Isokinetic Dynamometer, leg extension and low row **Functionality:** SFMA **Body composition:** DXA **Psychosocial:** FACIT-Fatigue, FACT-B	Unsupervised Home-based intervention	**Frequency:** 1–4x week **Intensity:** Aerobic, 40%–65% of heart rate reserve; resistance, 12–15 repetitions per exercise beginning with the light-strength or medium-strength band **Time:** Aerobic, increased from 15 to 30 min; resistance, N/A **Type:** Aerobic, walking; resistance, upper body exercises included lateral and front raises, wall or modified floor push-ups, chest press, bent row, arm curls, and triceps stretches; lower body included chair squats, chair leg raises, hamstring curls, and calf raises primarily with resistance bands; core exercises included the bridge, crunches, reverse crunches, and obliques	**Education:** Participants were given an exercise training workbook that included weekly exercise logs, the exercise training plan, illustrations of black breast cancer survivors engaging in resistance exercises and stretches, as well as motivational quotes **Culturally tailored material:** Newsletters were mailed monthly over 4 months, each focused on a specific exercise-related topic: goal setting, exercise benefits, exercise barriers, and social support **Motivation:** Participants were given a heart rate monitor and accelerometer along with weekly motivational phone interviews	76% completion	**Improvements seen in:** Total minutes of weekly physical activity ($P = 0.001$), cardiorespiratory fitness ($P = 0.01$), left arm flexion ($P = 0.03$) and extension ($P < 0.001$), and left ($P < 0.001$) and right ($P = 0.005$) leg extension, functional movement ($P = 0.005$) **No improvements seen in:** FACIT-Fatigue ($P = 0.31$), FACT-B ($P = 0.17$)
Mama et al. 2017 (41); 89 Hispanic breast cancer survivors	**Social cognitive theory variables:** Exercise self-efficacy, cancer survivors' exercise barriers self-efficacy scale, social modeling, social support for exercise survey **Physical activity:** IPAQ, PAST	Unsupervised/supervised Primarily home-based; group-based sessions held monthly	**Frequency:** 2x week **Intensity:** Based on participants' baseline fitness assessments **Time:** Based on participants' baseline fitness assessments **Type:** Aerobic exercise, muscular strength, and flexibility training	**Education:** Exercise group received biweekly phone calls and newsletters **Culturally tailored material:** Culturally adapted intervention included tailored newsletters to Latinas and breast cancer survivors	57.5% attendance	**Improvements seen in:** Main effect for time for self-efficacy ($P = 0.003$), moderate-intensity ($P = 0.007$), vigorous-intensity ($P = 0.013$), and total ($P = 0.003$) physical activity; time by site interaction for social support from family ($P = 0.011$); association between change in SCT variables and changes in physical activity and sedentary time, both unadjusted ($P = 0.031$) and adjusted ($P = 0.046$)
Hunley et al. 2018 (49); 19 black breast cancer survivors	**Quality of life:** SF-36 health survey **Self efficacy:** NIHSE **Balance:** Functional reach (BALANCE) **Pain:** UPAT **Upper extremity function:** QDASH	Supervised	**Frequency:** 1x week **Intensity:** Low **Time:** 1 h **Type:** Yoga	N/A	94.7% retention	**Improvements seen in:** SF-36 mental health ($P = 0.034$), BALANCE ($P < 0.0001$), acute pain ($P = 0.003$) **No improvements seen in:** Self-efficacy ($P = 0.09$), upper extremity disability ($P = 0.25$), SF-36 physical limitations to roles ($P = 0.37$), and fatigue ($P = 0.18$)

TABLE 1. Continued.

Author, Sample Size, Population	Outcome Variables	Intervention Setting	Intervention FITT	Additional Intervention	Adherence/ Retention	Results[a]
Piacentine et al. 2018 (38); 12 black breast cancer survivors	**Functional endurance:** 6MWT and sit-to-stand for 30 seconds **Body composition:** BMI	Supervised/unsupervised indoor/outdoor urban community center; home-based	**Frequency:** 5x week, a professional-directed 2x week sessions and provided detailed training of 3x week at home **Intensity:** Moderate to vigorous **Time:** 1.5 h **Type:** Walking/jogging, stair climbing, leg and arm exercises, stretching, agility, and balance exercises	**Education:** Educational seminars lasting 15 to 20 min were delivered weekly by content experts **Social:** 1-h focus groups were held before and after exercise	Exercise attendance averaged approximately 70%	**Improvements seen in:** 6MWT ($P = 0.021$) **No improvement seen in:** Sit-to-stand ($P = 0.052$) and BMI ($P = 0.318$)
Taylor et al. 2018 (31); 33 black breast cancer survivors	**Depression:** CES-D-R 10 **Fatigue:** BFI **Insomnia:** Insomnia severity index **Stress:** PSS	Supervised	**Frequency:** 1x week **Intensity:** Low **Time:** 1.25 h **Type:** Restorative yoga	N/A	61% adherence	**Improvements seen in:** Depression compared to the control group ($P < 0.01$) **No improvements seen in:** Sleep quality ($P = 0.89$), fatigue ($P = 0.75$), or perceived stress ($P = 0.77$) between groups

FITT = frequency, intensity, time, type; BMI = body mass index; 1RM= 1-repetition maximum; reps = repetitions; DXA = Dual-energy X-ray Absorptiometry; MV = muscle volume; CT = computed tomography; BFI = Brief Fatigue Inventory; FACT-P = Functional Assessment of Cancer Therapy-Prostate; PSA = prostate-specific antigen; 5RM = 5-repetition maximum; IPAQ = International Physical Activity Questionnaire; SFMA = Selective Functional Movement Assessment; FACIT-Fatigue = Functional Assessment of Chronic Illness Therapy-Fatigue; FACT-B = Functional Assessment of Cancer Therapy–Breast; PAST = Past-day Adults' Sedentary Time; SCT = social cognitive theory; SF-36 = Short Form-36; NIHSE = National Institutes of Health Toolbox Self-Efficacy Computer Adaptive Test Age 18+; UPAT = Universal pain assessment tool; QDASH = Quick disabilities of the arm, shoulder, and hand; 6MWT = 6-minute walk test; CES-D-R 10 = Center for Epidemiologic Studies Short Depression Scale; PSS = Perceived Stress Scale

[a]Improvement defined as significant change as reported by original author

adherence rate remained positive at 82% (24). This is promising for future research because Hispanic women appear motivated and willing to commit to a 3-day-per-week clinic-based high-intensity interval training intervention while undergoing chemotherapy (24). However, given these studies were not specifically focused on minority populations it is difficult to extrapolate definitive conclusions.

Resistance Exercise

Patients with cancer commonly experience muscle loss, which can negatively affect survival (25), and resistance exercise can act as a potential method to deter this loss (Tables 2 and 3) (26,27). Further, androgen deprivation therapy (which slows the growth of a hormone-dependent tumor in prostate cancer patients), also suppresses endogenous testosterone, which effectively reduces muscle mass and strength (28). Given these declines in strength and function that follow a cancer diagnosis and treatment strategies (29), resistance exercise is a critical modality to bolstering survivorship. Research across nonminority cancer patients demonstrate increased muscular strength, lower body fat, and increased lean mass (27), all potentially leading to an improved QOL (30). However, despite these benefits, studies that us resistance exercise alone are severely lacking among black and Hispanic cancer survivors. To our knowledge, only 1 study has examined the effects of resistance exercise in a minority population (26). This study involved a cohort of black men with prostate cancer on androgen deprivation therapy (n = 17) (26). Participants completed 12 weeks of 3 d per week of supervised resistance exercise training. Hanson et al. (2013) reported no changes in testosterone levels, despite significant improvements in muscle hypertrophy, muscular endurance, power, improved QOL, decreased fatigue perception, physical function, and improvements in sex hormone-binding globulin (26). This suggests that physical function may be improved without changes in blood testosterone levels during resistance exercise in black patients with prostate cancer on androgen deprivation therapy. The overall intervention appeared to be well received with a 95% adherence rate (26), indicating an interest of black individuals to partake in this kind of exercise. This type of exercise training also seems to be superior in decreasing fatigue (38%) compared to other studies reviewed that used aerobic only or combination exercise (13,22,31). However, no evidence in the Hispanic community has explored resistance only exercise, despite the most commonly diagnosed cancer in Hispanic men being prostate cancer (21%) (11). Those diagnosed were more likely to present with advanced-stage prostate disease when compared to non-Hispanic white men (9). Resistance exercise could also potentially influence and benefit cancer populations known to have severe muscle wasting (i.e. gastrointestinal cancer [32] and liver cancer [33]).

Combined Aerobic and Resistance Exercise

Combination exercise that uses both resistance and aerobic exercise elicits greater benefits for weight loss, fat loss, and cardiorespiratory fitness than aerobic or resistance exercise alone in noncancer patients (Table 2) (34). Combination aerobic and resistance exercise is well received among cancer survivors across numerous studies, with a myriad of beneficial results including improvements reported in QOL and physical fitness in breast cancer survivors (35) and presurgical cancer patients (36), increased bone health in female cancer survivors (37), as well as improvements in postoperative outcomes in presurgical cancer patients (36), and increases in six-minute walk test distances across prostate cancer survivors (38).

An equal divide by race/ethnicity was found among the 6 studies we identified that examined combination exercise interventions; 2 studies involved blacks (13,38), 2 examined mixed populations that included blacks and Hispanics (39,40), and 2 included Hispanics (41,42). Spector et al. (2014) and Piacentine et al. (2018) both studied black breast cancer survivors (n = 17 and n = 12, respectively) with a focus on physical activity and measures of cardiorespiratory fitness and functional endurance and movement. The authors included unsupervised home-based (13,38) exercise and incorporated additional days of supervised exercise at an urban community center (38). Supplementation to exercise occurred in the form of motivational (13), cultural (13), educational (38), and social (38) pieces. Spector et al. (2014), conducted a progressive home-based intervention lasting 16 weeks combining walking sessions with full-body resistance exercise via resistance bands (13). Piacentine et al. (2018) incorporated a team-based intervention where participants completed group exercise sessions with trainers 5 times per week for 14 weeks. Two sessions were supervised in a community center, and 3 sessions were home-based (38). Both studies elicited above 70% adherence, along with increased functional endurance (38), cardiopulmonary fitness (13), muscle strength (13), and functional movement (13). Spector et al. (2014) also used accelerometers and the International Physical Activity Questionnaire (IPAQ) to capture physical activity and reported a 544% increase in IPAQ despite only a 36% increase in accelerometry (13). Although the physical activity levels measured by IPAQ and accelerometers were significantly correlated in black cancer survivors following 16 weeks progressive aerobic and resistance intervention, baseline values were not correlated (13). Despite the higher cost and logistical complexity of wearable devices such as accelerometers, self-reported physical activity data may not accurately reflect participants' physical activity levels, especially before the exercise intervention, possibly due to unfamiliarity with the instrument and reporting bias. In addition, home-based exercise training may be less effective for psychosocial outcomes as demonstrated by failing to reach statistical significance despite improved QOL scores (13).

While not designed to primarily target minority participants, diverse sample populations were studied by Rossi et al. examining patterns and amounts of physical activity (39,40). These populations included 41% black and 18% Hispanic in a study of 99 endometrial cancer survivors (40) and 32% black and 28% Hispanic in a study of 28 obese

TABLE 2. Exercise intervention trials with diverse samples of cancer survivors (minority and high-risk populations).

Author, Sample Size, Population	Outcome Variables	Intervention Setting	Intervention FITT	Additional Intervention	Adherence/ Retention	Results
Moadel et al. 2007 (48); 128 breast cancer patients; 42 black (33%), 31 Hispanic (24%)	**Quality of life:** FACT-G **Fatigue:** FACIT-Fatigue **Spiritual and existential well-being:** The Functional Assessment of Chronic Illness Therapy–Spiritual **Mood:** Distressed Mood Index	Supervised Available at 3 locations within the cancer center CD provided for at home practice	**Frequency:** 1x week (participants allowed to attend more sessions per week if desired) **Intensity:** Low **Time:** 1.5 h **Type:** Hatha yoga	N/A	69% attendance 71% reported practicing yoga at home 1 or more times per week	**Improvements seen in:** Subscale social well-being ($P < 0.018$) **No statistical significance in:** Fatigue, spiritual, existential well-being, and mood (P values not reported)
Rossi et al. 2015 (40); 99 endometrial cancer survivors; 41 black (41%), 18 Hispanic (18%)	**Prevalence and patterns of physical activity:** Needs assessment filled out at physicals **Physical outcomes:** BMI, blood pressure	Supervised University recreation center	**Frequency:** 1x week **Intensity:** Each exercise was instructed with options for increased or decreased intensity to maximize individualization of the workouts **Time:** 1 h **Type:** Aerobic and resistance exercise with elastic bands	N/A	83% adherence	The primary motivations to exercise for participants were improving health (48%), losing weight (26%), and feeling better physically (21%) **No improvements seen in:** Body mass ($P = 0.10$), systolic blood pressure ($P = 0.10$)
Rossi et al. 2016 (39); 28 obese endometrial cancer survivors; 9 black (32%), 8 Hispanic (28%)	**Physical activity:** YPAS **Body composition:** BMI, waist circumference **Physical function:** 6MWT, 30-second chair stand test **Quality of life:** FACT-En **Social cognitive theory variables:** 10-item Self-Efficacy of Walking Scale, 9-item self-efficacy for exercise scale, behavioral regulations in exercise questionnaire, social support and exercise questionnaire, 9-item outcome expectations for exercise questionnaire	Supervised/unsupervised Albert Einstein College of Medicine fitness center; home	**Frequency:** Supervised, at least weekly exercise sessions; unsupervised, 1x week **Intensity:** Supervised, moderate to vigorous; unsupervised, assessed using pedometer **Time:** Supervised, 1 h; unsupervised, 1.5 h **Type:** Supervised, 25 min of dance fitness and 20 min of resistance exercise with body weight and resistance bands; unsupervised, participants were asked to walk at least 1.5 h per week outside of class	**Group counseling:** 30 min included in each class **Bilingual staff:** Classes were taught by a Hispanic black woman fluent in English and Spanish	60% adherence	**Improvements seen in:** Main effect of time for the YPAS Summary Index ($P < 0.01$), 6MWT main and interaction effects ($P < 0.01$), FACT-En main effect of time ($P = 0.05$) and interaction effects ($P < 0.01$), walking self-efficacy main effect of time ($P = 0.02$) and interaction effect ($P = 0.03$), self-determination main effect of time ($P < 0.01$), outcome expectations ($P < 0.01$), waist circumference interaction effect ($P < 0.01$) **No improvements seen in:** Interaction effect of YPAS ($P > 0.2$), chair stands ($P > 0.2$), FACT-G ($P = 0.13$), barrier self-efficacy, self-determination, and social support ($P > 0.2$); main effect of time in waist circumference ($P > 0.2$), FACT-G ($P > 0.2$), barrier self-efficacy, outcome expectation and social support ($P > 0.2$)

TABLE 2. Continued.

Author, Sample Size, Population	Outcome Variables	Intervention Setting	Intervention FITT	Additional Intervention	Adherence/ Retention	Results
Dieli-Conwright et al. 2018 (42); 100 breast cancer survivors; 55 Hispanic (55%); Parent Trial, JCO	**MSY:** Waist circumference, systolic and diastolic blood pressure, HDL-C, triglycerides TG, and glucose **Sarcopenic Obesity/ Body Composition:** ASMI assessed by DXA **Circulating biomarkers:** Insulin, IL-6, IL-8, TNF-α, IGF-1, leptin, adiponectin	Supervised	**Frequency:** 3x week (aerobic and resistance 2x, aerobic only 1x) **Resistance and aerobic** **Intensity:** Resistance, 80% 1RM for lower body and 60% 1RM for upper body; aerobic, 65%-80% HRmax **Time:** ~80 min, aerobic sessions increased from 30 (week 1) to 50 min (week 16) **Type:** Resistance, leg press, chest press, lunges, seated row, leg extensions, triceps extensions, leg flexion, biceps curl in circuit fashion; aerobic, treadmill walking/running, rowing machine, stationary bike **Aerobic only** **Intensity:** 65%–80% of HRmax **Time:** ~50 min **Type:** Treadmill walking/ running, rowing machine, stationary bike	N/A	95% adherence	**Improvements seen in:** All MSY variables, sarcopenic obesity, and all biomarkers when compared with baseline and usual care ($P \leq 0.01$); at 28-week follow-up, all biomarkers remained significantly improved in the exercise group when compared with baseline ($P < 0.01$)
Dieli-Conwright et al. 2018 (42); 100 breast cancer survivors; 55 Hispanic (55%); secondary analysis, BCR	**Physical Fitness:** Single-stage submaximal treadmill test, 10-repetition maximum **Bone Health:** DXA, BSAP and osteocalcin, CTX, NTX, RANK, RANKL, calcium and 25-hydroxyvitamin D **Psychosocial:** FACT-B, SF-36, BFI, CES-D	Same as Parent Trial	Same as Parent Trial	N/A	Same as Parent Trial	**Improvements seen in:** Estimated VO_2max, RHR, and muscle strength improved in exercise group compared to baseline and usual care group ($P < 0.001$); all physical fitness measures remained significantly improved at follow-up in exercise group compared to baseline ($P < 0.001$); osteocalcin and BSAP improved in exercise group compared to baseline and usual care group ($P \leq 0.05$); FACT-B, FACT-G, SF-36, fatigue and depression improved in exercise group compared to baseline and usual care group ($P \leq 0.01$); at follow-up all patient reported outcomes remained improved in exercise group compared to baseline ($P < 0.001$) **No improvements seen in:** BMD ($P > 0.10$), calcium and 25-hyroxyvitamin D ($P = 0.09$) in exercise group

TABLE 2. Continued.

Author, Sample Size, Population	Outcome Variables	Intervention Setting	Intervention FITT	Additional Intervention	Adherence/ Retention	Results
Lee et al. 2019 (24); 30 female breast cancer patients undergoing anthracycline-based chemotherapy, 22 Hispanic (73%)	**Cardiorespiratory fitness:** VO_2max, PPO	Supervised	**Frequency:** 3x week **Intensity** 1 min high-intensity (90% PPO) followed by 2 min of active recovery (10% PPO) **Time:** 30 min **Type:** Bike	N/A	82.3% adherence	**No improvement seen in:** VO_2max or PPO
Ray et al. 2018 (22); 7 colorectal cancer survivors, 2 black (29%)	**Cardiorespiratory fitness:** Symptom limited progressive exercise test, 6MWT **Quality of life**: SF-36 and FACT-C **Fatigue:** FACIT-F **Symptoms:** BSI **Bowel function:** Memorial Sloan Kettering Cancer Center BFI	Supervised in laboratory	**Frequency:** 2x week **Intensity:** Week 1–4: 50%–60% of VO_{2peak}, week 5–8: 60%–70%, week 9–12: 70%–80% **Time:** Week 1–4: 20–25 min, week 5–8: 25–35 min, week 9–12: 35–45 min **Type:** Cycle ergometer	**Interviews:** Participated in one-on-one interviews, completed in a private office or on the phone, lasting 15–25 min regarding past and present attitudes and beliefs regarding exercise	96% session compliance	**Improvements seen in:** VO_{2peak} ($P = 0.011$), VCO_{2peak} ($P = 0.007$), minute ventilation ($P = 0.010$), breathing frequency ($P = 0.02$), higher workload ($P = 0.037$) and longer time to exhaustion ($P = 0.013$) post-training, SF-36 physical component ($P = 0.04$) **No improvements seen in:** 6MWT ($P = 0.37$), SF-36 mental health, FACT-C ($P = 0.407$), FACIT-F ($P = 0.262$), BSI ($P = 0.283$), BFI ($P > 0.05$)

FITT = frequency, intensity, time, type; FACT-G = Functional Assessment of Cancer Therapy General; FACIT-Fatigue = Functional Assessment of Chronic Illness Therapy-Fatigue; BMI = body mass index; YPAS = Yale Physical Activity Survey; 6MWT = 6-min walk test; FACT-En = Functional Assessment of Cancer Therapy – Endometrial Cancer; JCO = journal of clinical oncology; MSY = metabolic syndrome; HDL-C = high density lipoprotein cholesterol; TG = triglycerides; ASMI = appendicular skeletal muscle index; DXA = dual-energy X-ray absorptiometry; 1RM = 1-repetition maximum; HRmax = maximum heart rate; BCR = breast cancer research; BSAP = bone-specific alkaline phosphatase; CTX = C-telopeptide of type 1 collagen; NTX = N-telopeptides of type 1 collagen; RANK = receptor activator factor-kappa B; RANKL = receptor activator factor-kappa B ligand; FACT-B = Functional Assessment of Cancer Therapy-Breast; SF-36 = Short Form-36; BFI = Bowel Function Instrument; CES-D = Center for Epidemiologic Studies-Depression Scale; RHR = resting heart rate; BMD = bone mineral density; PPO = peak power output; FACT-C = Functional Assessment of Cancer Therapy Scale-Colorectal; FACIT-F = Functional Assessment of Chronic Illness Therapy-Fatigue; BSI = brief symptom inventory

TABLE 3. Future directions.

Research Area	Examples
Patient Characteristics	
Cancer Diagnosis	Colorectal cancer
	Kidney cancer
	Liver cancer
	Skin cancer
	Head and neck cancer
	Thyroid cancer
	Hematologic cancers
	Genitourinary cancers
	Gastrointestinal cancers
	Prostate cancer
	Breast cancer (triple negative)
Age	Pediatric patients
	Adolescent and young adult patients
	Geriatric patients
Sexual Gender Minorities	Lesbian
	Gay
	Bisexual
	Transgender
Exercise Timing Across the Cancer Spectrum	
Time of Intervention	Presurgical
	During chemotherapy and/or radiation
	After completion of treatment
Type of Exercise Intervention	
Modification of Modality	Aerobic ± resistance exercise
	Resistance exercise only
	Interval or circuit training
	Alternative exercise: yoga, pilates, tai-chi, Zumba, kick-boxing, etc.
Outcomes	
Biomarkers	Metabolism
	Immunology
	Tumor progression
	Insulin resistance
	Glucose metabolism
	Cardiovascular (troponin)
Cancer Treatment	Tolerability to cancer treatment
	Toxicity of cancer treatment
Compliance/Barriers	Supervised vs unsupervised
	Community vs clinical based
	Distress
	Fatigue
	Anxiety
	Social economic status
	Difficulty with healthcare system

endometrial survivors (39). Both studies performed supervised exercise (39,40). The intervention was exercise classes once per week for 8 weeks and included both aerobic and resistance exercise with resistance bands (40). However, Rossi et al. (2015) examined a 12-week intervention consisting of home-based walking once a week and twice weekly supervised fitness classes using body weight exercises and resistance bands and included group counseling and bilingual staff (39). Rossi et al. (2016) reported a significant improvement in 6-min walk test by 5% (39). Despite the additional supplementation to the exercise, Rossi et al. reported higher adherence, 83% (40) in the group with no counseling or bilingual staff compared to 60% (39) in the study with counseling and bilingual staff.

Combined resistance and aerobic exercise interventions focused on Hispanic cancer survivors assessed outcomes including minutes of physical activity (41) and metabolic syndrome (42). Mama et al. (2017) used a cultural intervention in the form of phone calls and newsletters (41). These calls and materials were tailored to Hispanics with breast cancer (n = 89), whereas the nonculturally adapted group received standard newsletters (41). Both groups completed 16 weeks of twice weekly home-based exercise that included walking and use of resistance bands (41). Attendance of exercise sessions was 58%, with 84% of the newsletters received and read (41). The study, conducted out of 2 urban metropolitan areas, Houston, Texas and San Juan, Puerto Rico, also reported that study site affected the change in social support the participants experienced. Women in Texas reported a 2% decrease in social support from family from baseline to follow-up, while women in Puerto Rico reported 22% increased family social support (41). In addition, Dieli-Conwright et al. (2018) reported the effects of a combined aerobic and resistance exercise intervention in a sample of breast cancer survivors (n = 100), of which 57% self-identified as Hispanic. Participants exercised thrice weekly for 16 weeks in a clinic-based model, under direct supervision of a certified cancer exercise trainer. Aerobic exercises included biking, rowing, or treadmill walking/running, and resistance exercises included both free-weight movements and machine-based exercises, determined via submaximal strength testing. Despite the relatively high time commitment and strict exercise parameters when compared with home or community programs, adherence was extremely high at 95% in the Hispanic and non-Hispanic participants (42). The exercise group experienced significant improvements in QOL, fatigue, depression, estimated VO_{2max}, muscle strength, osteocalcin, and bone-specific alkaline phosphatase when compared to controls (42). This study stands out as the only one included in this review to report the benefits of exercise on blood-based biomarkers in minority cancer survivors. Hispanic breast cancer survivors improved their relative metabolic syndrome more than non-Hispanic breast cancer survivors from a 16-week supervised, structured, combined aerobic and resistance exercise intervention. Hispanic ethnicity was found to moderate the mean differences in exercise training on triglycerides, glucose, and C-reactive protein (43).

Alternative Exercise Modalities

Yoga is becoming an increasingly popular form of alternative exercise modality for cancer patients (44). Yoga offers benefits such as improving depression and anxiety disorders (45), decreasing heart rate and blood pressure, weight loss, increasing muscle strength, and reducing cortisol levels (46). However, racial/ethnic minorities and individuals of low social economic status tend to practice yoga less frequently, as yoga is most commonly practiced among white, college educated, female adults (47).

To date, 3 studies have focused on yoga practice in minority cancer survivors, all including black breast cancer survivors (31,48,49). In a 12-week study by Moadel et al. (2007), 128 participants (33% black, 24% Hispanic) practiced yoga once a week at a cancer center, with permission to do so more frequently (48). Participants were given a CD and asked to practice yoga daily at home. Despite 71% of participants reporting practicing yoga at home at least a few times per week, one-third of participants (31%) attended 0 classes. When assessed by ethnic group, a larger proportion of Hispanic (56%) women, compared with black (26%) and white (17%) women, did not attend the yoga classes (48). Taylor et al. (2018) used an intervention with a once-weekly yoga class at a university for 8 weeks, with a 61% adherence rate, and depression scores improving by 46%, assessed by Center for Epidemiologic Studies-Depression Scale (31). Lastly, Hunley (2018) used once weekly yoga for 6 weeks with classes led by occupational therapists (49). Adherence was not reported for this study, however retention was high at 94.7%, with a 50% reduction of pain measured by the Universal Pain Assessment Tool (49).

In summary, aerobic exercise prescription, with or without supplementation of behavioral and/or cultural tailoring, remains undefined for minority populations. Blacks tend to adhere well to cycling and walking interventions, while Hispanics have yet to be specifically targeted with aerobic exercise modalities. Resistance exercise remains underexplored in minority cancer populations, and therefore strict implementation of this exercise modality highlights an important area of focus for future studies. The combination of resistance and aerobic exercise is the most common type of exercise intervention among minority cancer survivors, and high adherence in all trials may show that a mixed modality is preferred among minority cancer survivors. While the benefits of yoga are readily recognized, few studies focus on yoga for minority cancer survivors. Given the mixed results of adherence and retention, future studies may benefit from focusing on recruitment and retention strategies to bolster adherence and should broaden their targeted population to include Hispanics. The results presented here underscore a need to develop culturally sensitive instruments to properly evaluate the effect of exercise interventions.

BARRIERS TO EXERCISE

While most Americans understand the benefits of exercise; barriers exist across all persons when it comes to engaging in exercise (50). Some factors that influence participation

include advancing age, low income, lack of time and motivation, being overweight or obese, and having the perception of poor health (50). Understanding barriers is an essential component to engage the community to adopt a more active and healthy lifestyle. Identifying barriers can assist with finding solutions and possibly shifting an individual's perspective to focus more heavily on the benefits of exercise instead of the barriers or disbenefits (51).

While the benefits of exercise are widely known among Hispanics, this has not translated into greater participation (50). Barriers within the Hispanic community remain varied, however common barriers to participating in exercise include time constraints and environmental access to fitness equipment and facilities (50). Perception of time coupled with home and family roles and responsibilities can greatly affect an individual's beliefs about their time and capability to engage in exercise. Constraints of time paired with environmental factors such as neighborhood safety and access to facilities can make the ability to exercise even more challenging. Black communities frequently cite child care and monetary costs as barriers to engaging in exercise (52). This is especially true for low income individuals that may face transportation challenges or inflexible work hours (52). A review of barriers in black women emphasized this finding as the review reported the 2 primary reasons for lack of time to exercise was due to work schedules and family/caretaking responsibilities (53). An individual's priorities will greatly affect their participation in what they deem luxury behaviors (54), which can make participation in healthy lifestyle behaviors challenging.

While common barriers among black and Hispanic populations may differ, it is important for researchers to understand the upbringing of certain communities, as this can affect perspectives of exercise. To bolster engagement in these communities, it may be beneficial for experts to better understand social interactions, roles and responsibilities, and access to exercise equipment, as well as values and beliefs of their participants (50,53).

Within the scope of participation in clinical trials conducting exercise, the National Institutes of Health (NIH) Revitalization Act of 1993 decreed that minority populations must be included appropriately in all NIH-funded research. Even so, the proportion of minority to majority participants in cancer clinical trials remains low (55). Clinical trials are valuable methods of identifying the best treatment and prevention options under precisely maintained conditions for those who have been afflicted by cancer and those who are still battling the disease. Without representation in these clinical trials, minority health disparities due to cancer are likely to continue or increase.

Barriers to trial participation for minorities have been delineated into a system level, individual level, and interpersonal level framework (56). The system level addresses the barriers that appear on the scale of healthcare systems and hospitals, including a limited number of active trials, limited infrastructure and resources to support or fund the trials, and narrow eligibility criteria for participants (56). Minority patients often receive care from more underresourced hospitals where little clinical trials are available and often are not eligible because of comorbidities. The individual level addresses the risks perceived by the healthcare provider, the patient, and the family as well since social support and recommendation from friends play a significant role in trial accrual (56). Above other barriers, providers are likely to be wary of cultivating mistrust with minority patients upon refusing the clinical trial offer, even though research shows that minority patients accept participation of clinical trials just as often as white patients (56). Some providers also have been shown to exhibit implicit bias when caring for minority populations; specifically, they are prone to assume that minority patients will not comply with some component of the clinical trial, such as abiding by the treatment regimen or keeping appointments (56).

The minority patient has a list of potential barriers at the individual level as well, the most relevant of these is being concerned about insurance coverage and travel distance to the trial site (57). Many minority cancer patients are either insufficiently insured or uninsured altogether, resulting in financial burdens that may deter trial participation. Moreover, the greater the distance of the trial site from the patient's home, the less time for work. This will have a more immediate consequence for low-income minorities and families, an urgent priority especially when childcare is not accessible. Transportation options might also be lacking. Additionally, minority patients may have negative, race-related attitudes toward providers fueled by a history of racism, uninformed consent, and poor healthcare for minorities in the United States (56). This can contribute to a heightened sense of mistrust in clinicians and a greater chance of refusing an offer to participate in a clinical trial. Finally, patients may not even be aware of the trial or may not know they are eligible.

The interpersonal level is a product of the system and individual levels of barriers, both from the patient and the provider (56). If the provider exhibits implicit bias, it contributes to the manifestation of adverse communication behaviors such as shorter and shallower interactions and a weakly patient-centered conversation (56). These provider behaviors fail to facilitate comfort or trust from the minority patient (57). Ultimately, a multilevel intervention is recommended for the best potential of success in trial recruitment (56).

Of the studies reviewed, 6 touched upon or addressed specific barriers through use of group-based exercise held at either a community center (23,38) or church (23), educational material (23,38), counseling (33,39), transportation passes (58), and weekly check-ins (13). Implementation of additional methods should promote exercise to be delivered in community and/or church settings to encourage social support (50) and address distance restrictions based on successes of previous studies (59). Incorporation of familial dyads can strengthen the social support within and outside of a research setting (50,60,61), keeping participants engaged, invested, and motivated. Inclusion of racial/ethnic support groups is another support mechanism that could provide participants advice, education, and motivation outside of family and friends (62,63). Table 4 lists the barriers and intervention designs that could be used in future research.

TABLE 4. Strategies to reduce exercise barriers in minorities.

Intervention Design Considerations	Barriers Addressed
Transportation vouchers (i.e. public transit tickets/passes, reimbursement)	Distance restrictions, financial burden, transportation resources
Exercise in community centers/churches	Distance restrictions, financial burden, social support, motivation
Group-based exercise	Social support, financial burden, motivation
Counseling	Social support, psychosocial support, motivation
Use of familial dyads	Social support, psychosocial support, motivation
Support groups	Social support, psychosocial support, motivation
Weekly check-ins	Motivation, education, social support, psychosocial support
Educational material	Motivation, education, psychosocial support

GAPS, ONGOING CLINICAL TRIALS, FUTURE DIRECTIONS

While there has been an increase in exercise oncology studies involving minority populations recently, there is still much to be investigated in order to offer generalizable exercise prescriptions that will benefit the diverse group of cancer patients. Division of studies by racial/ethnic demographics show a heavier emphasis on black cancer patients (13,22,23,26,31,38–40,48,61–66) than any other racial/ethnic group (39–41,48,67). This focus impedes the overall ability of exercise oncology to extend to all minority patients as there is not enough evidence gathered to definitively conclude the ideal prescription for many racial/ethnic groups, black individuals included. An imbalance of studies also exists for the breast cancer population (13,23,24,31,38,41,42,48,65,66), and specifically black breast cancer survivors (13,23,31,38,48,65,66). This disproportion of studies focused on breast cancer may be caused by the fact that breast cancer is one of the most common cancers diagnosed within the United States (68), and the most commonly diagnosed cancer among black women (31,64). Triple negative breast cancer is one of the most aggressive breast cancers (69) and encompasses 15% to 20% of all cases (70), with the highest prevalence being in black women (69). As seen in Tables 2 and 3, roughly half of the studies reviewed targeted minorities patients, while the other half encompassed samples that included minorities but did not focus on this population specifically.

Within the trials reviewed large discrepancies remain in the age range of cancer patients that were studied. To our knowledge, no studies specifically targeted adolescent and young adult or geriatric cancer populations. In the adolescent and young adult population, survival rates have increased over the years, with overall 5-year survival increasing by 80%. This improvement in survival is often accompanied by cancer-related side effects, resulting in potentially life-long adverse health consequences (71). Common side effects afflicting this population include increased risk of cardiovascular disease (72), physical deconditioning, cognitive changes, functional deficits, and negative impacts on psychosocial functioning (71). While there is growing evidence of exercise as an effective treatment (71), nearly 60% of young adults diagnosed with cancer during childhood, adolescence, or young adulthood remain sedentary (73). Geriatric cancer patients may gain exercise-induced health benefits. Approximately 50% of cancers diagnosed in the United States are in persons ≥65 years of age (74), with a high prevalence of comorbid conditions among these elderly patients (75), such as hypertension, diabetes, and obesity (76). Cancer treatment increases the risk for poorer function and physical decline (77); these declines, specifically grip strength and gait speed, have been linked with survival (78); however, no studies have been conducted in older minority patients. Given that exercise has been shown to improve physical function (77), conducting exercise interventions in this age range could potentially decrease the risk of physical and functional decline while also improving survival.

CONCLUSION

While research to date supports a multitude of benefits of exercise on psychosocial health, physical fitness, and biomarkers related to prognosis, few exercise trials include or specifically target minority cancer survivors. However, early results are promising among primarily black breast cancer survivors demonstrating improvements in physical activity participation, muscle strength, body composition, and psychosocial health. Future investigations should explore exercise in the presurgical setting and during chemotherapy or radiation treatment, include survivors with a diagnosis other than breast cancer, across the lifespan, and use novel exercise strategies in a multicenter design with inclusion of culturally tailored educational and behavioral components.

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