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Abstract

Exercise can improve quality of life (QOL) in breast cancer survivors. In contrast to many group or home-based exercise programs, little is known about the effectiveness of goal-oriented recreational activities.

Purpose

The purpose of this study was to evaluate a clinically overseen team triathlon training program on improving physiological and psychosocial health-related measures in female breast cancer survivors.

Methods

Twenty-three participants (age = 48 (8), BMI = 25(1), mean (SE)) were recruited from a 14-week sprint triathlon (800-m swim, 20-km bike, 5-km run) team training program for women breast cancer survivors (4 (3) years post-surgery, chemo-, or radiation-therapy). Training included two supervised group and three home-based individual sessions per week. Pre- and post-training outcomes included isokinetic knee extensor strength (60, 180, and 300° s^{-1}), 6-min walk test (6MWT), maximal oxygen uptake (VO_2 max), QOL (Functional Assessment of Cancer Therapy -Breast (FACT-B)), and barriers to exercise. Outcomes were also obtained 6 months post except for VO_2 max. Significance was set at $p < 0.05$.

Results

Data are mean (SD) from 21 complete data sets. Knee extensor peak torque significantly improved only at 300° s^{-1} (pre 40.3(8.5) ftlb; post 45.2(8.4); $p = 0.001$). 6MWT significantly improved (pre 632.8(62.1) m; post 657.4(53.2); $p = 0.014$) as did VO_2 max (pre 31.3(5.8) ml kg^{-1} min^{-1}; post 35.9(5.8); $p < 0.001$). FACT-B also improved (pre 114(12); post 122(13); $p = 0.004$), including the FACT-G total score, social well-being, and breast cancer subscales while barriers to exercise decreased (pre 54(12); post 36(9); $p < 0.001$). Strength, 6MWT, and barriers to exercise remained improved after 6 months.

Conclusions

Team triathlon training in breast cancer survivors can increase aerobic capacity and improve QOL which may contribute to healthier lifestyles in breast cancer survivors.

Keywords

Multisport, Exercise, Physical activity, Cancer survivorship, Quality of life

Introduction

Breast cancer is the most commonly diagnosed form of cancer and the second leading cause of cancer-related deaths in women in the USA [1]. Nevertheless, advancements in technology and medical care have significantly increased 5-year survival rates up to 89% depending on the type and stage of breast cancer [1]. Consequently, there are 3.1 million American breast cancer survivors [2]. These survivors may be burdened by post-treatment weakness, fatigue, scarring, lymphedema, and threat of recurrence, all of which may negatively affect quality of life (QOL) [3, 4]. Further, breast cancer survivors are at increased risk for weight gain and obesity; this increased risk can contribute to cardiovascular disease [5, 6], which may adversely impact overall survival.

Exercise in breast cancer survivors improves physical and psychological function resulting in increased QOL [7, 8]. The beneficial role of exercise or physical activity in cancer survivorship has become so well accepted that exercise guidelines now exist [9]. Furthermore, achieving these levels of physical activity has been shown to be feasible, safe, and reduce the risk for all-cause mortality [9, 10].

Most of what is known about the beneficial effects of exercise comes from investigation of structured exercise in supervised group or home-based programs [7, 11]. In contrast, with the exception of dragon boat racing [12-15], little has been reported on recreational games, sports, or outdoor activities, many of which are more readily accessible and could appeal to and be appropriate for breast cancer survivors.

Triathlon is a recreational sport that has experienced rapid participant growth [16]. A triathlon is a multisport event that comprises swimming, bicycling, and running. Growth in triathlon participation has been dramatic as the number of events targeting all ages has increased. Membership in USA Triathlon, the governing body of triathlon in the USA, has seen an increased membership for women from 27% in 2009 to 36.5% in 2013 [16]. Recently, the National Collegiate Athletic Association approved triathlon as a collegiate sport for women [17]. Finally, the appeal of triathlon to women is demonstrated by a number of women-only triathlons such as the Danskin Triathlon or Athleta Iron Girl Women's Only Sprint Triathlon. These women-only events are often categorized as sprint triathlons that typically comprise swim distances of 400-800 m, cycling distances of 20-30 km, and a 5-km run. Sprint triathlons are promoted with an emphasis on participation as opposed to competition per se and often have a health-related charity aspect including womens' health. These sprint triathlons, while challenging, present an accessible goal for the recreational athlete.

Triathlon training because of its multisport or cross-training nature offers particular benefit to the breast cancer survivor in addition to meeting the requirements for physical activity or aerobic conditioning [18].

Water and cycling exercise are both weight-supported activities that when alternated with running can lessen risk of injury from chronic weight-bearing orthopedic impact, a particular advantage for individuals who are overweight or deconditioned. Furthermore, swimming offers upper body strength, conditioning, and range of motion not provided by cycling or running. Finally, running, or even intermittent jogging, can provide necessary weight-bearing impact, to help maintain bone mineral density [9, 19-22] in breast cancer survivors. Thus, the cross-training aspect of triathlon may lead to benefits that a single-training modality might not with respect to aerobic conditioning, strength, and safety.

A unique aspect of a triathlon training program could be the development of a team and psychosocial support including autonomy, relatedness, competence, and other beneficial aspects of group exercise [23]. Accordingly, the goal of this pilot study was to evaluate the feasibility and efficacy of a sprint triathlon training program on improving psychosocial and physiological health-related outcomes in women breast cancer survivors.

Methods

Subjects

Women, ages 27 to 60, treated with or nearing the end of locoregional and systemic treatment for stage 0 to III breast cancer, were invited through an integrated community-based healthcare system to take part in a sprint-distance triathlon training program. Eligibility criteria for participation in the triathlon training program included the following: women with a history of invasive cancer or ductal carcinoma in situ, medical clearance to participate in moderate- to high-intensity exercise, having completed breast cancer surgery (including therapeutic resection and/or staged breast reconstruction, if performed) at least 4 weeks prior, and completion of any radiation therapy or cytotoxic chemotherapy at least 3 weeks prior to the program. Participants were not to have orthopedic contraindications, require supplemental oxygen, have a peripherally inserted central catheter, and undergo surgery, cytotoxic chemotherapy, or radiation during the training program. Ongoing cytostatic treatment was not an exclusion, and many participants were on targeted therapy (i.e., trastuzumab and/or pertuzumab) or hormonal therapy (i.e., a selective estrogen receptor modulator (tamoxifen) or an aromatase inhibitor). All participants had to provide medical clearance to participate in exercise of moderate to high intensity. Written informed consent, approved by the University's Institutional Review Board, was obtained

from each subject to take part in the research described below. Age, height, weight, and abdominal circumference, measured with a spring-loaded measurement tape at the level of the umbilicus, were obtained from each subject.

Triathlon training program

The triathlon training program consisted of 14 weeks of a summer training program and culminated in an all-women sprint distance triathlon consisting of an 800-m inland lake swim, 20-km bike, and 5-km run. The team sought to create an environment where personal hurdles were overcome by becoming a part of a social group facing similar struggles (e.g., post-mastectomy scarring, radiation- or chemotherapy-induced fatigue) with a common goal of completing an athletic event of personally significant magnitude. One woman had previously participated in a triathlon event, and another was an endurance runner.

Participants took part in a 14-week program that physically and mentally prepared them to participate in a sprint distance triathlon. Twice weekly, 90-min, group training was designed and supervised by certified triathlon coaches and supported by physicians, physical therapists, exercise physiologists, nurses, and other community and medical volunteers. The 90-min sessions were divided into 45-60 min of aerobic activity with the remaining time spent in core exercises, lifestyle management, or verbal/mental coaching. Camaraderie was fostered by having the previous year's participants (breast cancer survivors who had completed a pilot program the prior year) serve as "workout buddies" both during the group training workouts and during individual workouts as needed.

Exercise training intensity was based on heart rate training zones established on day 1. While the same group training plan was given to everyone, exercise was individually progressed within the allotted group and individual sessions, based on initial fitness levels. Progression of duration, frequency, and intensity was based on the goal of completing the targeted triathlon and was consistent with American College of Sports Medicine guidelines [24]. Training intensities were within the range of five to eight metabolic equivalents (METs) corresponding to moderate/vigorous activity. Individual workouts were prescribed for three to four of the remaining unsupervised days of the week. These individual workouts, totaled 3 to 7 h per week, were periodized and focused on swimming, biking, walking, jogging, running, and building core strength. Coaches met with participants weekly to aid with compliance. Thus, the training program had elements of group and individual exercise training sessions within the context of a team.

Some of the participants were nave or beginner swimmers. Swim training included technique and endurance swim sessions in both pool and open water. For those few participants who did not own a bike, a local bicycle store loaned and fitted bicycles to participants. Cycling sessions covered cycling technique, safety, and basic maintenance. Post-mastectomy swimwear was fitted for each woman and also donated. Individual treatment side effects were taken into consideration by the clinicians and coaches, including scarring or fibrosis caused by surgery and radiation, deconditioning, and altered metabolism associated with early menopause. A core of volunteer clinicians was present at each group workout to address any clinical or informational concerns and to provide emotional and physical therapeutic support.

Design summary

Self-report and physiological measurements were obtained prior to training and within 2 weeks of the completion of the sprint triathlon event. To gain insight into whether any beneficial effects of were sustained, measurements were also completed 6 months after completion of the triathlon (6 months post). For logistical reasons, maximal oxygen uptake was only measured pre- and post-triathlon.

Questionnaires

Breast cancer health-related QOL was obtained using the 37-item Functional Assessment of Cancer Therapy - Breast (FACT-B) questionnaire [25]. This questionnaire has been validated to assess multidimensional QOL in breast cancer survivors [25]. This questionnaire consists of the Functional Assessment of Cancer Therapy-General (FACT-G), validated for cancer survivors with any form of cancer, and a series of breast cancer-specific QOL questions [26]. In turn, the FACT-G comprises physical, social, emotional, and functional well-being subscales. All of these subscales can be derived or calculated from the FACT-B to allow comparisons to other studies, in the case of the FACT-G, or otherwise to aid in interpretation of results. To provide insight into possible barriers to regular physical activity, subjects reported subjective barriers that interfered with exercise [27, 28]. This questionnaire consisted of 21 questions regarding barriers to exercise (time, weather, fatigue, lack of skills, etc.). Responses were based on a five-point Lickert scale from 1—never to 5—very often and where higher scores were associated with greater perceived barriers. Responses were summed.

Strength

Lower extremity strength or peak knee extensor torque production was measured with an isokinetic dynamometer (Biodex System 3, Biodex Medical Systems, New York). Subjects were seated in a comfortable position with hip and knees at 90 flexion and with dominant leg and torso secured with straps. Knee extension and flexion of the dominant leg were performed throughout each subject's range of motion. Five unilateral right knee extensions and flexions each at 300, 180, and 60° s^{-1} (5.2, 3.1, and 1.0 rad s^{-1}) in order were performed with 10-s rest between each speed. Subjects were provided with verbal encouragement. A warm-up at identical speeds to the test preceded the test. Analyses were performed within each speed for these isokinetic strength measurements to quantify strength changes after training.

Aerobic capacity

To test whether or not the triathlon training resulted in an aerobic training effect as well as to compare with other studies, we assessed the 6-min walk test (6MWT) and maximal oxygen uptake as indicators of functional and maximal aerobic capacity, respectively [29]. The 6MWT was measured as the distance walked over a 30-m course in a hallway for 6 min. Subjects were provided with periodic feedback of how much time remained [29].

Maximal oxygen uptake was measured using open-circuit spirometry. Subjects walked on a motorized treadmill at a constant self-selected walking speed. Grade was increased by 2.5% every 2 min until voluntary exhaustion. Volume and composition of expired gas were measured with an automated metabolic cart (Vmax Encore Systems, Software v 20-1a, Yorba Linda, CA) that was calibrated before each test with known gas concentrations. The criterion for successful test completion was two out of the following: an RQ ≥ 1.1, reaching 85% age-predicted maximal heart rate (HR) based on the equation "Maximal HR = (220age)", and an oxygen uptake plateau or increase <5% of a preceding stage. Heart rate was monitored continuously by ECG, and brachial blood pressure was obtained every 2 min by manual sphygmomanometry.

Statistics

Analyses were by repeated measure ANOVA followed by paired comparisons if appropriate or paired t tests for physiological measures (SPSS v 20). Friedman tests were used for questionnaires across all three time periods. If the Friedman tests were significant, then pairwise comparisons to baseline were also examined in a post hoc fashion using Wilcoxon signed-rank tests. Comparisons only to baseline were a priori determined so as to diminish type 1 error. To further protect against type 1 error, FACT-B subscale analyses were only performed if the FACT-B Friedman test was significant. Significance was accepted as $p \leq 0.05$. Data are mean (SE) or median (minimum, maximum).

Results

Twenty-five women provided informed consent and completed baseline testing. Prior to the triathlon event, two subjects withdrew: one due to family commitments and one for a non-training-related injury. All 23 remaining participants completed the training, entered and completed the triathlon. Two participants did not complete post-triathlon measurements: one due to scheduling and one for unrelated medical reasons. Analyses consisted of complete data sets of 21.

Participants

Participants had a mean age of 48 (8), with a range of 27 60 years. Women were 4 (3) years post-treatment with a range of 0.5 to 10 years. Clinical and anthropometric characteristics are provided in Tables 1 and 2, respectively. The 21 participants were heterogeneous with respect to breast cancer stage

Table 1 Clinical characteristics of 21 breast cancer survivors

Variable	No.
Cancer stage	
Stage 0	1
Stage I	8
Stage II	10
Stage III	2
Treatment	
Surgery	21
Adjuvant chemotherapy	16
Adjuvant radiation therapy	13
Adjuvant hormonal therapy	11

and treatment. There was no change in height, weight, BMI, or abdominal circumference post-triathlon though there was a downward trend in BMI.

Questionnaires

Self-reported health-related QOL improved after the triathlon training as indicated by the overall increase in FACT-B scores (Table 3). Furthermore, post hoc analyses of the component subscales also indicated significant improvements post-triathlon in FACT-G, social well-being, and breast cancer sub-scales. There was a trend toward improvement in physical and emotional well-being (both $p = 0.06$). Improvements in FACT-B and FACT-G total scores were within the range of minimally important differences [30, 31]. Self-reported barriers to physical activity significantly decreased by about 33% (Table 3).

Strength

As shown in Fig. 1, isokinetic peak torque of the knee extensors increased only after training at the fastest 300° s^{-1} speed (main effect, $p = 0.01$) with no significant improvements at speeds of 180° s^{-1} (main effect, $p = 0.27$) or 90° s^{-1} (main effect, $p = 0.32$).

Table 2 Subject anthropometry before and after triathlon training

	Baseline	Post-triathlon	*p*
Height (cm)	164 (1)	163.9 (1)	0.61
Weight (kg)	65.4 (2)	63.3 (3)	0.45
BMI	25.0 (1)	24.6 (1)	0.12
Abdominal circumference (cm)	84.0 (2)	84.5 (2)	0.61

There were no significant differences in anthropometry (N = 21) after triathlon training compared to baseline pre-training measurements. BMI body mass index where BMI = kg m^{-2}. Data are mean (SE)

Table 3 Self-reported quality of life and barriers to activity before and after triathlon training

	Baseline	**Post-triathlon**	**6 months post-triathlon**	**Friedman *p***
FACT-B	115 (86, 134)	122 (93, 141)**	122 (81, 137)	0.003
FACT-G	90 (72, 104)	94 (75, 107)*	92 (70, 106)	0.01
Physical well-being	25 (19, 28)	26 (22,28)	26 (18, 28)	0.03
Social well-being	23 (15, 27)	24 (17, 28)**	22 (16, 28)	0.03
Emotional well-being	20 (8, 24)	20 (10,14)	20 (14, 24)	0.28
Functional well-being	22 (16, 27)	23 (15, 28)	23 (12, 28)	0.34
Breast cancer subscale	27 (12, 32)	28 (18, 35)**	27 (11, 35)*	<0.001
Barriers to physical activity	55 (31, 90)	35 (21, 56)**	42 (26, 66)**	0.03

FACT-B, component subscale scores, and barriers to activity at baseline, post-triathlon, and 6 months post-triathlon in 21 women breast cancer survivors. p is overall effect by Friedman test. Pairwise comparisons to baseline by Wilcoxon signed-rank test where *p ≤ 0.05 compared to baseline and **p ≤ 0.01 compared to baseline. Values are median (minimum, maximum)

Aerobic capacity

Functional aerobic capacity, as indicated by the 6MWT, improved on average by 25 m (Fig. 2). Improvements in 6MWT were mirrored by the significant 15% increase (4.6 ml O_2 kg^{-1} min^{-1}) in mean maximal oxygen uptake presented in Fig. 3. While maximal oxygen uptake improved, respiratory exchange ratio (RER) and maximal heart rate were similar at baseline compared to post-triathlon.

Six months post-triathlon

All 21 subjects who completed the post-triathlon measurements also completed the 6 months post-testing. Despite a

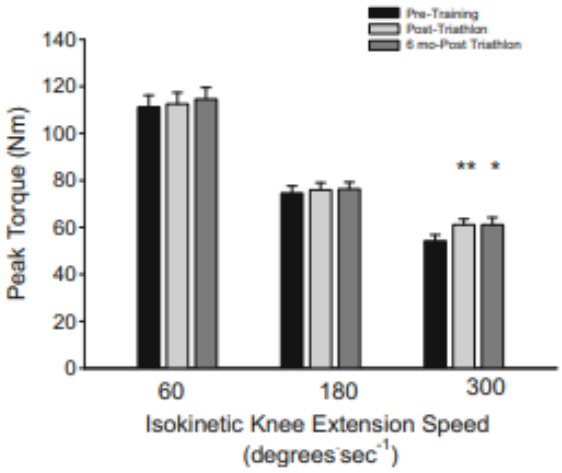

Fig. 1 Isokinetic peak torque of knee extensors before and after triathlon training in 21 women breast cancer survivors. Measurements were obtained at pre-training baseline, after participation in a sprint triathlon, and 6 months after the triathlon. Compared to baseline, torque was elevated at the fastest speed both post and 6 months post-triathlon. Data are mean (SE). Single asterisk indicates p ≤ 0.05 compared to baseline. Double asterisk indicates p ≤ 0.01 compared to baseline

significant overall effect, at 6 months post, the FACT-B was no different from baseline as was also the case with all subscales except the breast cancer subscale. In contrast, the decreased barriers to exercise from baseline noted at post-triathlon continued to be reduced from baseline at 6 months post-triathlon (Table 3).

The increased strength at the fastest test speed (300° s^{-1}) at post-triathlon compared to baseline was still increased over baseline at 6 months post as were improvements in the 6MWT (Figs. 1 and 2).

Discussion

This feasibility and initial efficacy pilot study shows that a clinically overseen, goal-oriented group training program for a sprint distance triathlon can improve QOL and physiological

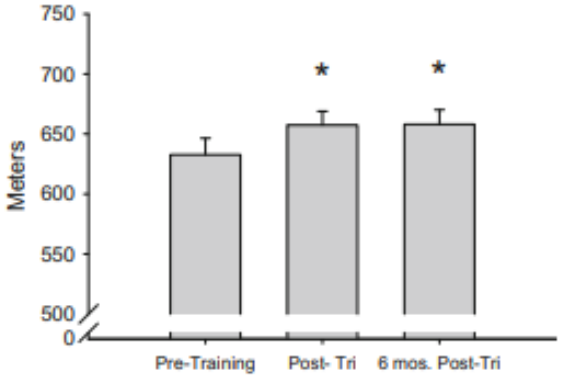

Fig. 2 Distance walked in 6 min (6-min walk test) before and after triathlon training in 21 women breast cancer survivors. Measurements were obtained at pre-training baseline, after participation in a sprint triathlon, and 6 months after the triathlon. Distance improved at both post and 6 months post-triathlon compared to baseline. Data are mean (SE). Asterisk indicates $p \leq 0.01$ compared to baseline

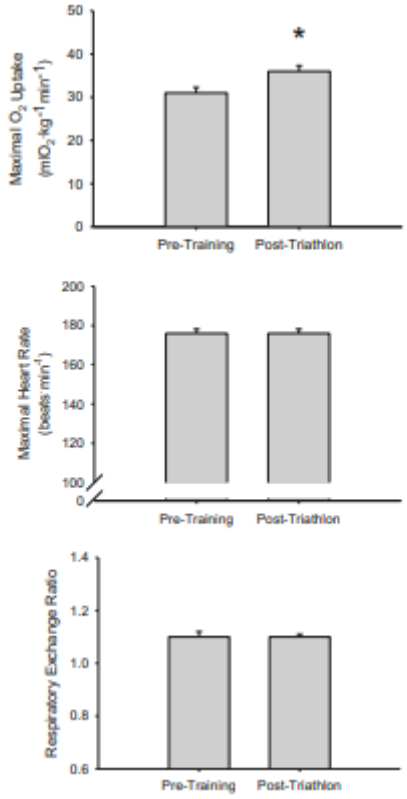

Fig. 3 Maximal oxygen uptake, maximal heart rate, and RER resulting from graded treadmill exercise in 21 women breast cancer survivors before and after triathlon training. Maximal oxygen uptake had increased by

~15% after triathlon training with no change in maximal heart rate or RER compared to pre-training baseline. Data are mean (SE). Asterisk indicates $p \leq 0.05$

outcomes in women breast cancer survivors. Furthermore, physical improvements related to exercise appear to be stable for at least 6 months after training ended.

The clinical heterogeneity of our subjects is reflective of the community outreach nature of the triathlon team and of breast cancer survivors in general. While this heterogeneity limits some specificity to our interpretations, it also suggests that the observed improvements in QOL and physiological outcomes are non-specific with respect to treatment type and clinical presentation at least so long as there are no contraindications to exercise in women breast cancer survivors. Such contraindications include extreme fatigue, or anemia, changes in arm or shoulder symptoms as well as general cardiovascular or pulmonary contraindications [9].

Current recommendations for exercise or physical activity for cancer survivors include 150 min of moderate-intensity exercise or 90 of vigorous cardiorespiratory exercise [9]. Even a conservative estimate neglecting the individual sessions of training would suggest that the triathlon training described can come close to or possibly exceed these exercise recommendations.

Improvements in QOL were of a general nature as indicated by the FACT-G as well as specific to breast cancer survivors as indicated by improvements in the breast cancer-specific subscale. Overall, these results are similar to what has been reported in other exercise settings [7, 32].

Maximal oxygen uptake improved from training by ~15%. This increase is of similar magnitude to reported improvements in breast cancer survivors from other aerobic training studies [7, 32]. Consistent with this increase in aerobic capacity is the significantly increased 6MWT distance that persisted 6 months after program completion. Similar improvements in 6MWT have been reported in breast cancer survivors after exercise interventions [33, 34]. There was no associated change in weight despite improvements in strength and endurance. Basic and sports nutrition contents were presented during triathlon training, but weight loss per se was not specifically targeted. Weight loss could be incorporated into future iterations of a longer training program, and participants indicated this would be an important health-related goal.

We cannot entirely rule out a familiarity or other time-related effect to explain the increased aerobic capacity after training compared to baseline. However, after training, neither RER nor peak HR at the end of the treadmill tests differed. Thus, similar test endpoints were reached before and after triathlon training. These findings would argue that higher maximal oxygen uptake was the result of training and not to an improvement due to greater effort or motivation. If the latter, then an increased HR or RER from baseline might also have been observed post-triathlon.

The triathlon training included general and sport-specific conditioning, but resistance training per se was not incorporated into the program. Improved aerobic capacity was mirrored with improvement in knee extensor strength but only at 300° s^{-1}. The observation that strength improved only at this fastest speed tested suggests that improvements in isokinetic strength were activity specific.

An integral part of the triathlon training program was the presence of members of a participant's medical team. A majority of survivors of cancer prefer to receive exercise counseling from a clinically associated exercise specialist [35]. Nevertheless, positive changes in exercise behavior have been described in response to an oncologist's recommendation to exercise [36]. Further, beneficial changes in exercise behavior may be mediated by the presence of an exercise motivation package [37]. While we speculate that the presence of a clinical team during training may have contributed to the positive physical and QOL changes observed, perhaps through

increased self-efficacy and motivation, our experimental design does not allow specific insight into this potentially important component of training.

Physical benefits of triathlon training were still apparent after 6 months, although many of the QOL benefits regressed back to baseline. We propose that positive exercise behavior change was initiated during the training process and that the motivation to continue to be active was maintained for at least 6 months despite the absence of formal and regular team meetings. Evidence for continued motivation to be active is that perceived barriers to physical activity remained diminished from baseline even at 6 months. Subjects also reported maintained physical activity. Thus, from the standpoint of exercise or physical activity, training for and participating in a triathlon may be the catalyst for sustainable behavioral change.

In contrast, benefits to QOL may have resulted from specific social aspects and camaraderie afforded by team interaction and training [11, 23, 38]. Included in these factors could be a Hawthorne effect or change in behavior from having members of a participants medical team present (e.g., the patients breast surgeon). The formal group training aspects of the study ended after participation in a triathlon. However, participants took it upon themselves to remain in contact with one another on social media, to support each other in their future exercise goals. Perhaps, this post-triathlon support was enough to maintain individual motivation to exercise but not enough to realize full social benefits. Further targeted research is needed to determine if these suppositions of physical or psychosocial change are correct.

Team triathlon training can be considered analogous to dragon boat racing [13] which was one of the first activities to capture the public's imagination and promote exercise via leisure time activity in breast cancer survivors (e.g., [12-15, 39, 40]). In addition to physical benefits [39], dragon boat racing may mediate improved QOL through emotional well-being, self-confidence, camaraderie, and an altered view of cancer survivorship [15, 39, 40]. The similarity of triathlon training to dragon boat racing is evident in improved QOL measures as well as to the decreased barriers to exercise after triathlon training. One advantage of triathlon over dragon boat racing is that it does not require one to live near an area where dragon boat racing occurs. Triathlon and similar participatory events are prevalent and can take place virtually anywhere.

A limitation to the promotion of triathlon for breast cancer survivors is the expense of associated equipment and fees including bicycles, running shoes, swimsuits, and swimming pool and event entry fees. Nevertheless, once initially acquired, equipment needs are minimal. For our program, costs were mitigated by community partners and included loaner bicycles and donated post-mastectomy swimwear. Donors provided funding to cover coaching, while medical coverage for all of the training sessions was provided by volunteer medical and physical therapy staff. These partnerships may not be available in all settings.

Some participants were initially unsure of themselves in the water. While triathlon would not be appropriate for someone

who was fearful in open water, initial water practices in the pool were designed to increase comfort in the water and for some were "swim lessons." Oftentimes, the fears and anxieties related to surgery, chemotherapy, and radiation experienced during the patients breast cancer treatment were used as an analogy to help participants overcome any trepidation of swimming in open water, cycling over varying terrains, and endurance running.

Triathlon participation may not be for everybody, but it is likely that benefits from group triathlon training could extend to other multi- or single-sport events such as duathlon (running and cycling) or even a 5-km fun run. A run-cycle duathlon would be appropriate for someone not comfortable with swimming while a 5-km "fun run" only requires a good fitting pair of athletic shoes. In non-cancer populations, a recreational 3-km run training program has shown to promote short- and long-term physical activities [41], while as a goal-oriented group, half-marathon training program can change exercise-related behaviors [38].

Additional limitations include a small convenience sample with inherent selection bias and lack of a comparison group. Despite the small sample size, sufficient power was present to detect changes that would be associated with exercise in breast cancer survivors [9] and results are consistent with changes observed in other studies [7, 31-33]. As mentioned, triathlon training may not appeal to everybody and an inherent predisposition to this type of activity may contribute positively to our findings. Lack of a control group introduces uncertainty with respect to true changes due to training as well as calculating effect sizes. However, changes noted are consistent with previous results [7, 31-33].

We are aware that breast cancer survivors do participate in triathlons of all lengths, but this study is the first to describe the benefits of a clinically supported, community-based, group, goal-oriented triathlon training on physical function and QOL in breast cancer survivors. Further, there may be some carryover in these benefits even after the program has ended.

We conclude that a clinically supervised team goal-oriented sprint triathlon training program can be an apparently safe and effective method to promote exercise and QOL in women breast cancer survivors. Benefits include improving strength, aerobic capacity, and QOL for breast cancer survivors. Physical benefits in particular may be self-sustained after a program's end for at least 6 months and appear to be mediated at least in part by decreased perceived barriers to exercise.

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Compliance with Ethical Standards

Written informed consent, approved by the University's Institutional Review Board, was obtained from each subject to take part in the research.

Conflict of Interest

The lead author states that he has no financial relationship with the organization that sponsored the research. At the time of the study, several of the co-authors were employed by Aurora Health Care, the organization that administered the grant for the Vince Lombardi Cancer Foundation. No authors have a financial relationship with the Vince Lombardi Cancer Foundation. The lead author has full control of all primary data that contributed to this study, and it is available for journal review if requested.

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