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ORIGINAL REPORT

EVALUATION OF A SUPERVISED PHYSICAL ACTIVITY PROGRAMME FOR CANCER SURVIVORS: FROM TREATMENT TO TRIATHLON

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Objective: **It is recommended that cancer survivors incorporate physical activity into their daily lives after in-hospital rehabilitation. However, there is a lack of training programmes focusing on the specific needs of cancer survivors. TriaGO! – an 8-month intervention study of aerobic endurance training for cancer survivors – was therefore examined. The training programme aims to meet the participants' physical needs and provide socio-emotional support, in the form of an exercise programme that challenges participants to aim to compete in an Olympic-distance triathlon (1,000 m swimming, 45 km cycling, 10 km running) after 8 months' of training.**
Methods: **The TriaGO! training programme was provided to in-hospital rehabilitated cancer survivors ($n=12$). Each patient invited a healthy friend or family member to train with them (a so called buddy ($n=12$)). The 8-month programme involves supervised training sessions, combining cycling, swimming and running, which progress in frequency, duration and intensity. Physical health was measured at the start, 4 and 8 months, using objective parameters of aerobic fitness, muscular fitness and body composition.**
Results: **A total of 22 out of 24 participants successfully completed the training programme and the triathlon. Both the cancer survivors and their buddies showed significant improvements in physical health. Cancer survivors showed improvements in aerobic fitness, as increases in VO_2max and VO_2peak of 5.5 ml.kg^{-1}.min^{-1} and 0.26 ml.min^{-1} respectively ($p<0.0001$). Buddies underwent similar significant increases; 5.39 ml.kg^{-1}.min^{-1} and 0.18 ml.min^{-1}, respectively.**
Conclusion: **The TriaGO! training programme introduces the concept of supervised endurance training for cancer survivors. Through measurement of objective parameters, this study demonstrated that significant physical reconditioning is possible in cancer survivors. A supervised programme would be recommended for all cancer patients after in-hospital treatment, in order to facilitate the transition to incorporation of physical activity into daily life.**

LAY ABSTRACT

Following the rehabilitation of cancer survivors in hospital, there is need for training programmes that can be carried out at home, to help patients to incorporate physical activity into their daily lives The aim of this study was to measure the impact of a training programme of supervised physical activity for use after in-hospital rehabilitation. The training programme, designed to meet the physical needs of cancer survivors and provide socio-emotional support. It was offered to a group of 24 cancer survivors and their healthy buddies, with the aim of completing an Olympic-distance triathlon (1 km swimming, 45 km cycling, 10 km running) after 8 months. Supervised training sessions, combining cycling, swimming and running, were provided, increasing in frequency, duration and intensity. During the 8-month training programme the subjects' physical health was measured 3 times using objective parameters of aerobic fitness, muscular fitness and body composition. Out of 24 participants, 22 successfully completed the training programme and finished the triathlon. The excellent improvements in physical health achieved in this study demonstrate the feasibility of physical reconditioning in cancer survivors.

Key words: oncology; supervised training; triathlon; cancer survivors.

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Advances in cancer treatment have led to increased survival rates, as more people are cured of their disease or receive a favourable prognostic outcome. Hence, there is an increasing number of cancer survivors who have to deal with the harmful and persistent adverse effects of cancer and its treatment, which may affect their quality of life. Cancer survivors are consequently at increased risk of developing other chronic diseases, such as cardiovascular disease (1–3). Physical reconditioning is therefore recommended for cancer survivors. Oncology rehabilitation includes a wide range of therapies designed to build strength and endurance, to regain independence, reduce stress and maintain the energy to participate in daily activities.

The benefit of exercise interventions for cancer survivors is increasingly clear, and strongly supports the implementation of exercise in oncology rehabilitation programmes (4–7). Physical activity (PA) improves functional outcomes, relieving individual symptoms, improving the return-to-work potential, and, specifically, PA is associated with a reduction in cancer recurrence and an increase in survival (8–12). However, it remains unclear to whom, how and where exercise plans should be provided (13). The majority of oncology rehabilitation programmes are implemented while the patient is in hospital, and, after this period, patients are commonly advised to attend a sports club for further physical rehabilitation.

The worldwide availability of worldwide rehabilitation services is limited and currently no standardized model for oncological rehabilitation exists. Exercise programmes for cancer survivors, similar to cardiac rehabilitation programmes, have been shown to result in a 14% improvement in cardiorespiratory fitness in patients who have been treated for breast cancer (14).

Clinically relevant improvements in cardiorespiratory fitness related to PA are expressed as increases in peak oxygen uptake (VO_{2peak}) and maximum oxygen uptake (VO_{2max}) that have prognostic value (15). Muscular strength, as a strong predictor of mortality (16), is correlated with the risk of falls and fractures in cancer survivors (17). Also, there is promising evidence that weight management is associated with prevention of downstream sequelae in post-therapy cancer survivors (18).

In our experience, rehabilitated cancer patients often have difficulty in finding organized training programmes that focus on their specific needs, such as: continuation of the hospital rehabilitation programme; training provided in a location away from a health or sports club; training together with other patients; focussing on improving physical condition and quality of life.

To address this difficulty, the oncology department of the University Hospital Antwerp and AZ-Monica set up a programme called TriaGO!. This initiative proposes an intermediate path between in-hospital outpatient, structured, post-treatment rehabilitation and the recommended independent exercise. TriaGO! offers cancer survivors a supervised programme of aerobic endurance training for a period of 8 months, with the aim of completing an Olympic-distance triathlon (ODT) (i.e. 1,000 m swimming, 45 km cycling and 10 km running).

The aim of this study was to determine whether a supervised aerobic training programme, TriaGO!, can safely improve aerobic fitness in a group of cancer survivors. This study also explores the potential benefit of including healthy friends or family members to train alongside the cancer survior (so called buddies). The design of TriaGO! addresses outcomes of importance with respect to exercise in cancer survivors: aerobic fitness, muscular fitness, body composition, safety, adherence, social aspects, and quality of life. The training programme was assessed with a group of rehabilitated cancer survivors and a group of buddies.

METHODS

Study design and setting

TriaGO! is an 8-month intervention study of a group of rehabilitated cancer survivors patients and a group of buddies. Supervised exercise sessions are provided in a group, individually, or together with a personal buddy, and progress over time in frequency, duration and intensity. The ultimate goal is to participate in and accomplish an ODT in Knokke, Belgium. Professional guidance during training sessions was provided by a level A triathlon coach, assisted by a level B triathlon coach with a level A degree in swimming (VTS Flemish Coach School) and Polar V800 sports watches to collect data on training intensity (speed, heart rate). Screening of each participant was performed at the Department S.P.O.R.T.S., a study centre located at the University Hospital Antwerp.

Ethical approval

Ethical approval (B300201526566/UZA: EC 15/47/502) was provided by the ethics committee of Antwerp University Hospital. All participants provided informed written consent prior to study entry.

Participant recruitment

A total of 210 cancer survivors were invited by a written letter to a meeting about joining the TriaGO! programme. The meeting explaining the project was attended by 37 cancer survivors, of whom 22 stated an interest in participating. After the first eligibility check and the sportmedical screening, 12 cancer survivors were selected for participation and invited a healthy friend or family member to become a buddie.

Eligibility criteria

Initial eligibility criteria were: the absence of relevant medical history not related to cancer; a clear personal motivation and willingness to undergo an endurance training programme; and designation of a motivated personal buddy. This selection resulted in a total of 14 cancer survivors.

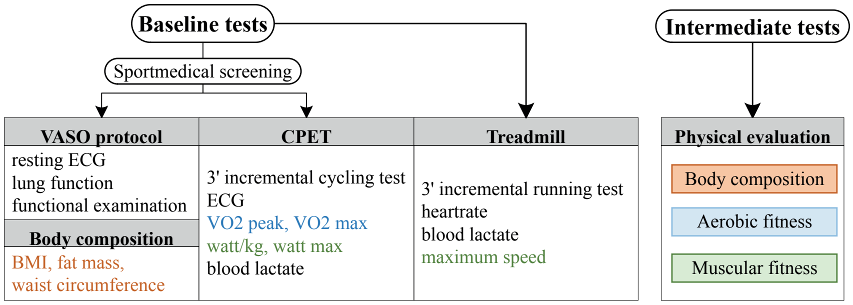

Fig. 1. Physical evaluation and test results at inclusion, baseline evaluation and intermediate physical evaluation. Inclusion variables used to measure: body composition (*orange*), aerobic fitness (*blue*) and muscular fitness (*green*). CPET: cardiopulmonary exercise testing; VASO: VASO: Vlaamse Aanbeveling Sportmedisch Onderzoek; BMI: body mass index; ECG: electrocardiography; VO_{2peak}: peak oxygen uptake; VO_{2max}: maximum oxygen uptake.

Sports medical screening

Inclusion of all participants (both cancer survivors and buddies) was dependent on the sports medical screening, based on the Vlaamse Aanbeveling Sportmedisch Onderzoek (VASO) protocol, according to the Flemish Sports Physicians guidelines, cardiopulmonary exercise testing (CPET), and body composition measures. **Fig. 1** shows details of these tests. The VASO protocol includes a rest-ECG (Schiller), a lung function test on the MIR Spirobank, resulting in forced vital capacity and Tiffeneau index, body mass index (BMI) (height (Seca, FysioSupplies.be), weight (CAE, care solutions, Schelle, Belgium) and a functional examination by a sports physician. During a 3-min progressive maximal CPET on a cyclo-ergometer (Lode Excalibur, Samcon BVBA, Melle, Belgium), measurements of both the cardiovascular and respiratory system were collected: ECG (Schiller, Arseus Medical, Bornem, Belgium), VO_{2max} and VO_{2peak} (Geratherm Ergostik, Accuramed BVBA, Halen, Beldium), blood lactate (EKF Diagnostics Lameris, Accuramed BVBA, Halen, Beldium) Wmax and relative power (W/kg). Sex-specific CPET indices were used for the cycling protocol: starting at 40 W, increasing each 3' with half of their body weight, with a maximum increase of 30 W for women and 40 W for men. The running protocol was tailored according to individual running experience. In case of limited or no running experience, the initial walking speed was 5.4 km/h, the first running stage was 8 km/h, with an increase of 1 km/h evey 3 min. In case of running experience of more than 8 weeks, the incremental increase every 3 min was 1.5 km/h.

When ECG irregularities were recorded, further investigations were performed at the cardiology unit to ensure safe inclusion. Two buddies were excluded based on medical findings (Brugada-syndrome and vascular abnormalities) and were replaced by 2 healthy buddies prior to the start of the study.

Baseline and intermediate tests

Physical condition was evaluated by cycling and running tests at 3 time-points: before the start of the endurance training programme (baseline), after 4 months training, and after 8 months training.

Aerobic fitness and muscular fitness were captured by CPET and treadmill tests, measuring VO_{2max}, VO_{2peak}, W_{max}, W/kg, maximum speed (treadmill (H/P Cosmos)). There was a minimum interval of 2 days between cycling and running tests. Body composition was determined by measuring BMI, waist circumference and fat mass (skinfold: Harpenden Skinfold Caliper – Durnin and Womersley formula). Fig. 1 illustrates the order of tests.

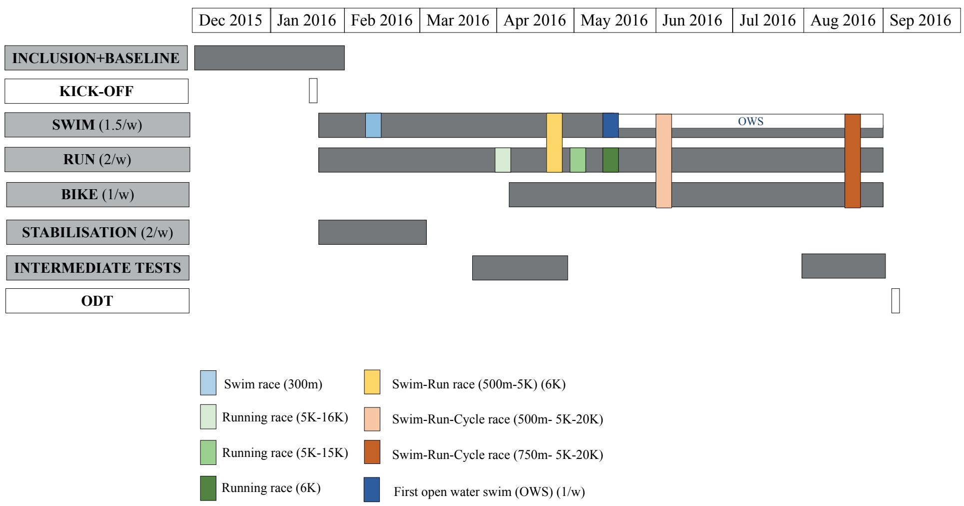

Fig. 2. Training programme design. Timeline of TriaGO! training sessions from inclusion to Olympic-distance triathlon (ODT), showing frequency per week (/w), intermediate races (*coloured boxes: see key*), and intermediate tests at 4 and 8 months after baseline. w: week; OWS: open-water swim.

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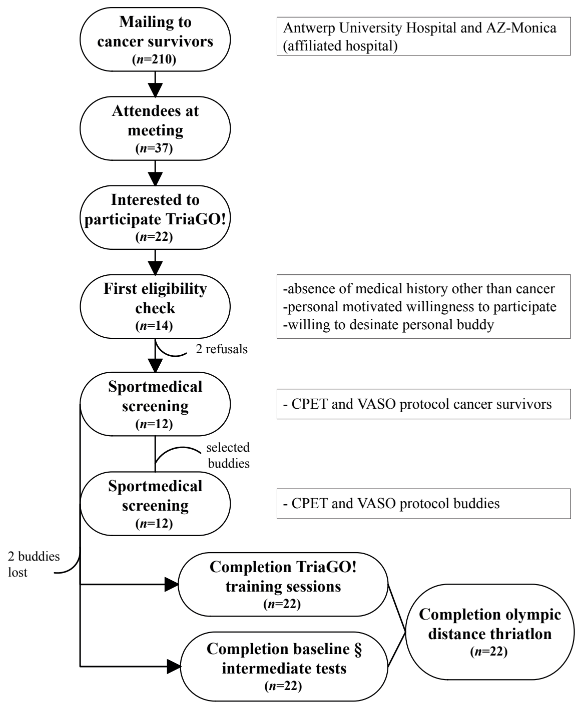

Fig. 3. CONSORT (Consolidated Standards of Reporting Trials) flow diagram of progress through the phases of participant inclusion and screening. CPET: cardiopulmonary exercise testing; VASO: Vlaamse Aanbeveling Sportmedisch Onderzoek.

Training programme

The TriaGO! training programme was started with 24 participants (12 cancer survivors and 12 buddies) in January 2016, with the endpoint being an ODT in September 2016. After inclusion and baseline tests the swim and run training sessions commenced, together with stabilization exercises. Cycle training sessions commenced later, in April 2016. **Fig. 2** illustrates the design of the training programme, the intermediate tests, and intermediate races. Races and supervised training sessions are undertaken in group together with buddies. Every participant receives also an individual training scheme and is free to train together with the buddie or alone. Training schedules took into account subject's lactate threshold, heart rate and maximum speed.

After completing the ODT all participants filled in a questionnaire about their quality of life. A short survey was carried out 2 years after the ODT, to determine the PA of all cancer survivor participants at that time.

Statistical analysis

Means and standard deviations (SD) of the outcomes are reported at different time-points. Progression over time (baseline, 4 months, 8 months) for all variables was evaluated for each group (cancer survivors and buddies). VO_{2max} and W_{max} were transformed into valid norms for males and females, according to the Shvartz-Reibold score (SR-score) (19) and Kuipers' index (20), respectively.

For all outcomes, a linear mixed model was fitted, using individual as a random intercept to correct for repeated measurements of the same person. Sex, time and group were used as fixed affects in the analysis. Time was entered as a categorical variable. For each of the models it was first tested whether the interaction was significant. If not, this was removed and the model was refitted. If time was significant 2×2 *post hoc* tests were used to compare the 3 different time-points, and adjusted *p*-values with Tukey correction for multiple testing were reported. R 3.3.2 (Microsoft open source) and SAS 9.4 (Analytics Software & Solutions, UK) were used for statistical analysis. Measured outcomes (body composition, muscular fitness and aerobic fitness) were recorded at the different time-points to demonstrate the change over time. Values are expressed as a ratio compared to baseline expressed as percentage.

RESULTS

Population characteristics

A Consolidated Standards of Reporting Trials (CONSORT) flow diagram for participants is shown in **Fig. 3**. Out of the 24 participants, a total of 22 successfully completed the training programme and finished the ODT. One buddy broke an arm during a cycling session in the final stage and another buddy withdrew voluntarily due to family issues.

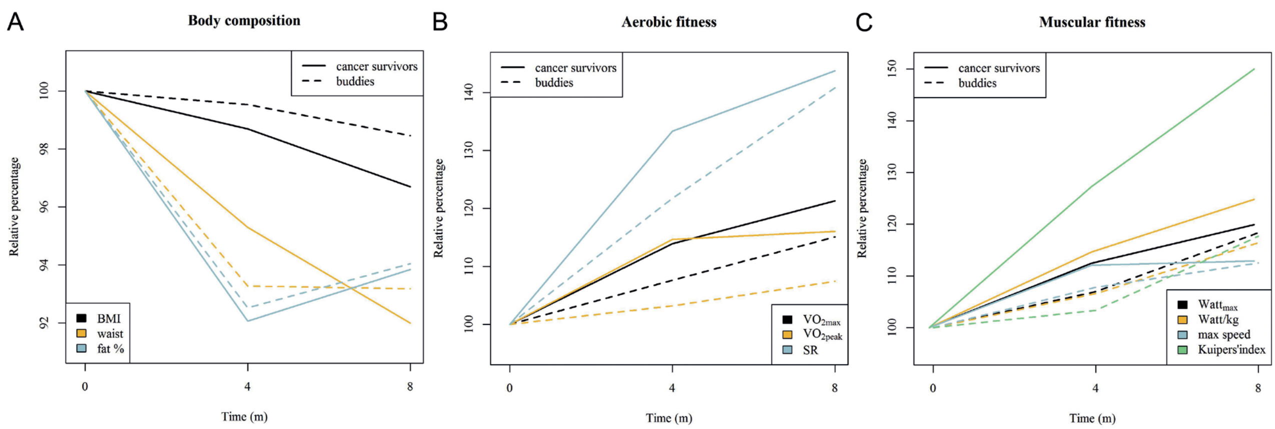

Fig. 4. Change in outcomes in cancer survivors and buddies over time, by category: (A) body composition, (B) aerobic fitness, and (C) muscular fitness, during the intermediate physical tests, showing ratios compared to baseline expressed as percentage. m: months; BMI: body mass index; VO_{2peak}: peak oxygen uptake; VO_{2max}: maximum oxygen uptake; SR-score: Shvartz-Reibold score. Solid lines: cancer survivors; dashed lines: buddies.

Table I. Participants' characteristics ($n=12$)

	Cancer survivors	Buddies
Cancer history, *n*		
Breast	9	
Colorectal	2	
Carcinoid	1	
Cancer treatment		
Surgery	1	
Surgery/chemotherapy	3	
Surgery/chemotherapy/radiation	8	
Median time post treatment, years	2.1	
SR-score, *n*		
Weak	1	1
Very moderate	1	2
Moderate	3	2
Average	3	2
Good	2	2
Very good	1	2
Excellent	1	1
Median age, years	47	40.5
Kuipers' index, *n*		
Weak	4	3
Very moderate	6	3
Moderate	1	5
Average	1	1
Good	0	0
Very good	0	0
Excellent	0	0
Sex, male/female, *n*	3/9	4/8

Cancer-related characteristics of cancer survivors (cancer history, treatment and post-treatment median time at start of training), and performance parameters (SR-score and Kuipers' index) at baseline for all participants, both cancer survivors and buddies

Participant's characteristics at baseline are shown in **Table I**. Physical condition at baseline related to aerobic fitness, expressed as SR-score, was moderate to average (mean score 3.91) for cancer survivors, and average (mean score 4) for buddies. The Kuipers' index, related to muscular fitness, was weak to very moderate (mean index 1.92) for cancer survivors and very moderate to moderate for buddies (mean index 2.33).

Physical performance

Changes in body composition, aerobic fitness and muscular fitness for both groups are shown in **Table II**. There was no significant difference in change over time of the measured outcomes between the groups (p-value interaction time and group >0.05 for all variables). However, there was a significant evolution over time of the physical condition of both cancer survivors and buddies (p-value time <0.05 for all variables). Table II reports the adjusted p-values for each of the 2×2 comparisons of the 3 time-points, and demonstrates a global improvement, as there were significant differences in mean values between baseline and endpoint after 8 months' training (right-hand column: 0 vs 8 m).

A global improvement in body composition was observed in cancer survivors, as a reduction in BMI of 0.97 kg/m^2, reduction in waist circumference of 7.54 cm, and reduction in fat mass of 2.13%. For buddies, similar reductions occurred (0.46 kg/m^2, 6.05 cm and 1.52%, respectively). The model found that these changes are overall (no distinction between groups) estimated as 0.72 (95% CI 0.20, 1.24), 7.08 (95% CI 4.47, 9.70) and 1.90% (95% CI 0.85, 2.95), respectively. No significant differences were observed for body composition when comparing 4 months with 8 months. Progression over time for all outcomes reflecting body composition are shown in **Fig. 4**A, expressed as percentage as a ratio compared with baseline.

Global improvement in aerobic fitness, as estimated from the model, comprises increases of VO_{2max} and VO_{2peak} of 5.55 ml.kg^{-1}.min^{-1} (95% CI 3.69, 7.40) and 0.26

Table II. Physical evaluation. Measured outcomes (mean (SD) at 3 time-points (baseline, 4 months, and 8 months) for both cancer survivors and buddies.

	Baseline		4 months		8 months		Global improvement baseline vs endpoint		Adjusted *p*-value		
Physical evaluation	Cancer survivors Mean (SD)	Buddies Mean (SD)	Cancer survivors Mean (SD)	Buddies Mean (SD)	Cancer survivors Mean (SD)	Buddies Mean (SD)	Cancer survivors, %	Buddies, %	0 vs 8 m	0 vs 4 m	4 vs 8 m
Body composition											
BMI, kg/m^2	25.49 (4.06)	24.96 (4.78)	25.09 (3.52)	24.17 (4.14)	24.53 (3.22)	24.28 (4.01)	0.97	0.46	**0.0044**	0.3229	0.1382
Waist circumference, cm	89.75 (11.9)	89.17 (11.42)	86.14 (8.56)	80.56 (7.81)	82.21 (8.96)	79.45 (6.12)	7.54	6.05	**<0.0001**	**<0.0001**	0.3965
Fat mass, %	33.42 (5.12)	29.82 (6.53)	30.84 (5.14)	27.39 (8.46)	31.29 (4.54)	27.76 (7.13)	2.13	1.52	**0.0002**	**0.0001**	0.667
Aerobic fitness											
VO_{2max}, ml/kg/min	31.53 (7)	35.92 (8.28)	34.55 (5.66)	40.22 (8.08)	37.45 (5.44)	42.36 (9.79)	5.93	5.39	**<0.0001**	**0.0003**	**0.0156**
VO_{2peak}, ml/min	2.31 (0.62)	2.62 (0.64)	2.47 (0.53)	2.75 (0.54)	2.64 (0.65)	2.85 (0.57)	0.33	0.18	**<0.0001**	**0.005**	0.3572
SR-score	3.91 (1.76)	4 (1.86)	4.6 (1.43)	4.9 (1.6)	5.09 (1.45)	5.25 (2.05)	1.18	1.38	**<0.0001**	**0.0009**	**0.0292**
Muscular fitness											
W_{max}, W	154.8 (46.72)	171.3 (51.77)	164 (40.55)	186.6 (43.68)	182.7 (47.17)	203.3 (54.25)	27.92	29.12	**<0.0001**	**<0.0001**	**<0.0001**
W/kg	2.21 (0.57)	2.45 (0.71)	2.45 (0.53)	2.72 (0.61)	2.67 (0.46)	2.88 (0.76)	0.47	0.34	**<0.0001**	**0.0033**	**0.0075**
Kuipers' index	1.92 (0.9)	2.33 (0.98)	2.27 (0.9)	2.7 (0.95)	2.58 (0.67)	3 (1.51)	0.67	0.50	**<0.0001**	0.1371	**0.0212**
Max speed, km/h	11.02 (1.53)	11.7 (1.95)	12.11 (1.25)	12.71 (2.11)	12.65 (1.44)	13.38 (1.87)	1.42	1.41	**<0.0001**	**<0.0001**	**0.04489**

Mean differences between baseline and endpoint values are shown in the "Global improvement" column for both groups. Improvements in body composition-related outcomes are procentual decreases, improvements for aerobic fitness and muscular fitness are procentual increases. The right-hand column shows adjusted *p*-values resulting from 2×2 comparisons of the different time-points for all participants together. (Bold font if significant). m: months; SD: standard deviation; BMI: body mass index; VO_{2peak}: peak oxygen uptake; VO_{2max}: maximum oxygen uptake; SR-score: Shvartz-Reibold score.

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ml.min–1 (95% CI 0.13, 0.40) respectively, for cancer survivors ($p<0.0001$). Similar significant increases for buddies were 5.39 $ml.kg^{-1}.min^{-1}$ and 0.18 $ml.min^{-1}$. These results correspond to an increase in SR-score of more than 1 for both groups (95% CI 0.76, 1.65), which means that the aerobic fitness norm shifts 1 category comparing baseline with endpoint (0 vs 8 months). Moreover, SR-score and VO_{2max} significantly improved at every intermediate test (see adjusted p-values comparing other time-points in Table II). The progression over time of all variables reflecting aerobic fitness is shown in Fig. 4B as relative percentages compared with baseline.

Global improvement in muscular fitness is reflected by increases in W_{max}, W/kg and maximum running speed from baseline to 8 months (all p-values <0.0001). After 8 months of training, an increase of 27.92 W and 0.47 W/kg occurred for the cancer survivors, which is comparable with the global improvement in the buddies, who showed increases of 29.1 W and 0.34 W/kg, respectively. Model estimates are 27.88 W (95% CI 21.44, 34.32) and 0.41 W/kg (95% CI 0.26, 0.56), respectively. The Kuipers' index also increased significantly, by 0.60 (95% CI 0.30, 0.91) for both groups, reaching the next category. The progression over time of all variables reflecting muscular fitness is shown in Fig. 4C as relative percentages compared with baseline.

DISCUSSION

This project investigated the impact of a supervised exercise training programme (TriaGO!) on aerobic fitness, muscular fitness and body composition in cancer survivors and their buddies. The programme combined cycling, swimming and running sessions with 7 intermediate races, 6 weeks' stabilization exercises and 2 intermediate physical tests. Intermediate physical tests examined individual aerobic fitness, muscular fitness and body composition after 4 and 8 months' training. The ultimate goal was to complete an ODT after 8 months of training. The group of participants that effectively started the ODT race, being 12 cancer survivors and 10 buddies, achieved this challenge sucessfully. TriaGO! showed that the physical condition of the group of cancer survivors improved over time, matching that of the group of buddies. This proofs that physicial reconditioning after cancer is possible.

The TriaGO! training programme introduces the concept of supervised endurance training for cancer survivors, in which close support by a personal buddy-participant is part of the programme. Although the buddies were personally chosen by each cancer survivor, this group was considered to constitute a control group for comparing change in objective parameters of physical condition. The participants' motivations for participating in the programme were: having a planned goal, exercise in a group, having professional (high-level) coaches, being physically challenged, and experiencing fun in participation in sport.

The functional capacity of the neuromuscular, cardiovascular and respiratory systems declines, on average, from 0.5% to 3.5% per year with age (21). In response to the TriaGO! training programme, equivalent positive changes in physical condition were determined from baseline to post-intervention (8 months), for both cancer survivors and their buddies. The change in VO_{2max} that is clinically significant to cancer survivors is unknown, but, in general, an increase of 3.5 $ml.kg^{-1}.min^{-1}$ is associated with a 17–25% decrease in risk of all-cause mortality (22). The results of the current study demonstrate a clinically meaningful improvement after the TriaGO! training programme (i.e. a mean increase in VO_{2max} of 5.55 $ml.kg^{-1}.min^{-1}$ (95% CI 3.69, 7.40)). In addition, the first intermediate test at 4 months, showed an increase in VO_{2max} of 3.27 $ml.kg^{-1}.min^{-1}$, demonstrating clinical relevance. Aerobic fitness norms increased by 1 category, from moderate to average, according to Shvartz & Reibold (19). In addition, the Kuipers' performance index, which is a sensitive parameter to detect differences in maximal aerobic power (20), demonstrated an overall improvement and shifted one category. For cancer survivors from 1 (weak) to 2 (very moderate) and for buddies from 2 (very moderate) to 3 (moderate).

The TriaGO! concept is in line with World Health Organization (WHO) guidelines, which encourage supervised training to enhance adherence with the programme and to prevent injuries. The outcome of the TriaGO! programme was maximized by using supervisors with experience in oncological rehabilitation and in the specific triathlon-associated sport activities. This is a different approach to that of standard rehabilitation programmes, based on instructions to complete exercises at home, for which it is known that cancer survivors do not attain this kind of health maintenance. There are a number of barriers to improving exercise participation, such as lack of facilities, mental difficulties, solitary exercises, or fear of doing harm (23). Supervised exercise could therefore help facilitate the transition to incorporating PA into everyday life after cancer, thus influencing long-term maintenance of health in these patients (24, 25). In addition, the concept of a buddy-participant appears to be advantageous. Before completing the ODT all participants reported a positive impact on their quality of life and, to date, TriaGO! participants have maintained lifestyle changes and exercise on a regularly basis, which is the ultimate goal.

Conclusion

The TriaGO! programme met the physical needs of cancer survivors after treatment and provided socio-emotional support. Through measurement of objective parameters, this study demonstrated that physical reconditioning is possible in cancer survivors. The physical performance of the cancer survivors and their buddies improved to the same extent. Physical rehabilitation remains an indispensable element in follow-up care after cancer treatment. A supervised programme is recommended for cancer patients after in-hospital treatment, in order to facilitate the transition to incorporation of PA into daily life.

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The authors have no conflicts of interest to declare.

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