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CLINICAL FEATURE
ORIGINAL RESEARCH

Dragon Boat training exerts a positive effect on myocardial function in breast cancer survivors

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Abstract

Introduction. Dragon Boat training is often suggested to control upper limb edema in breast cancer (BC) survivors, but little information is available regarding the cardiac impact of such activity. The present study evaluates this aspect during a 4-year follow-up of BC survivors. *Material and methods*. From 2006 to 2010, 55 women diagnosed with BC in 2005, treated with adjuvant therapy without evidence of metastases, were enrolled for competitive Dragon Boat training. They underwent ergometric tests yearly, and 2D echocardiography to evaluate hemodynamic, morphological and functional cardiac parameters. *Results*. The data were compared with those from a group of 36 healthy women (HW). Both groups maintained normal systolic function throughout the period, with Cardiac Mass index, Body Mass Index and Ejection Fraction values being higher in HW. At the onset of the study, the diastolic function of BC survivors was normal though compatible with initial diastolic dysfunction when compared to the diastolic function of HW. After 4 years of competitive activity, the diastolic parameters improved in both groups and particularly in BC survivors (A peak: from 68.5 ± 15.1 cm/s to 50 ± 14.1 cm/s, $p < 0.05$; Ea: from 9.3 ± 2 cm/s to 11.89 ± 1.7 cm/s, $p < 0.001$). *Conclusions*. BC survivors experienced a significant improvement in diastolic function after 4 years of Dragon Boat training. Dragon Boat training impacts favorably on the myocardial performance in patients previously treated with chemotherapy. These results support the positive role of sport activity in myocardial function of BC survivors.

Keywords

Sports activity, myocardial performance, breast cancer

History

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Introduction

Several observational studies of cancer survivors suggest that physical exercise can alleviate many effects and symptoms that are associated to the disease [1]. Fatigue, cognitive dysfunction and depression are positively influenced by regular exercise, with a marked improvement of the quality of life [2]. A question of interest in cancer rehabilitation setting is whether sport activity can help cancer survivors. The preserved myocardial function is one of the most important aspects strongly related to a normal quality of life, and therefore associated to regular physical activity.

Given its aerobic component and, in addition, its possible impact in controlling upper limb volume, Dragon Boat is one of the most frequently practiced sports among breast cancer (BC) survivors [3]. The BC community has enthusiastically embraced Dragon Boat racing as a form of rehabilitation [4]. At present, few data are available on the cardiovascular effects of this sport when regularly practiced over long periods. Investigating the cardiac effects of physical activity on a group of cancer patients would be an ideal model to answer this question, as long as the patients did not have life-threatening cardiac impairment. Having access to a number of local Dragon Boat team members in Florence, Italy allowed us to prospectively evaluate the functional status of the myocardium in a group of highly motivated BC survivors over an extended time period. Therefore, the present study investigated the morphological and functional cardiac modifications using ergometric tests and echocardiography in a group of BC survivors, after cancer treatment, who trained on a Dragon Boat team for 4 years. We also compared those results to those obtained from a control group of healthy women (HW) regularly participating in other types of sports during the same time period.

Materials and methods

From 2006 to 2010, 1 year after diagnosis of BC, chemotherapy and surgical treatment, a group of 55 asymptomatic women aged 57 ± 7 without evidence of metastases and in remission, no comorbidities at baseline and normal cardiac

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function were included in the present study. They trained regularly in competitive Dragon Boat teams, and all had been examined at yearly intervals at the Sports Medicine Center in Florence, Italy, as per legal requirements to assess their fitness to continue to practise sport. All subjects gave their oral consent to participate in the study. All the procedures described in the present study were approved by our Local Ethics Committee. None of them abandoned the protocol, and all were active parts of a sport team, and therefore regularly involved in seasonal competitions.

Surgical intervention for the BC group included total mastectomy of the affected breast (n = 15) and quadrantectomy (n = 40). Post-surgical treatment included conventional adjuvant chemotherapy (n = 26, chemotherapy only) for operable BC including: doxorubicin and cyclophosphamide or cyclophosphamide, methotrexate and 5-fluorouracile, or 5-fluorouracile, epirubicin and cyclofosfamide given for approximately three cycles, where one cycle is normally defined as cycle–course of therapy in monthly intervals. Only nine women of the BC group underwent pharmacological treatment consisting of aromatase-inhibitors. Radiotherapy had been administered to 46 patients, while 9 women had surgical intervention only. These drugs and radiation treatments can be cardiotoxic [5,6].

None of the BC survivors presented hypertension or diabetes, or were affected of an evident arm edema at the onset of the protocol. Training consisted of twice weekly 2 hour sessions that started with 10 minutes of moderate aerobic exercise followed by 90 minutes of practice in the boat, ending with 20 minutes of cooling down and stretching exercises. The control group of 36 HW practicing other sports [7] (21 running, 2 cycling, 5 tennis, 1 canoeing, 1 riding, 1 scuba diving, 3 swimming and 2 fitness) were also studied. The control group trained three times a week for at least 2 hour sessions. All study participants underwent a maximal incremental test performed according to the American Heart Association guidelines [8]. The test was carried out using a cycloergometer or a treadmill. The test terminated when the subject reached her maximum tolerable effort. Maximal heart rate (HR) was assessed during the incremental exercise test. For the cycloergometer test, an incremental Bruce Protocol (25 Watt/3 minutes) was used; for the treadmill test, the modified Bruce protocol was used with an increase of slope and speed every 2 minutes. Recordings were continued for 4 minutes after the end of the test.

HR and 12 lead Electrocardiogram (ECG) were recorded throughout the exercise and the rest period. Blood pressure was taken at rest and at each phase of physical effort. The ergometric test was concluded when the patient declared to have reached exhaustion or had reached 90% of predicted maximum HR for age and level of training. At the end of the test, the Double Product (DP), as expression of myocardial work proportional to myocardial oxygen consumption, was calculated from the maximal HR and systolic blood pressure (SBP) maximal values at peak effort. The echocardiographic study was conducted by two experienced board-certified cardiologists using a My Lab 50 echocardiograph (Esaote-Italy) equipped with a 2.5 MHz probe.

According to the American Society Echocardiography guidelines [9], all the systolic-diastolic left ventricle (LV) parameters were measured at rest as follows: interventricular septum, posterior wall thickness, the diameter of the LV in end-diastolic diameter (LVEDd), and end-systolic (LVESd) diameter, the right ventricle diameter from the parasternal long-axis projection (RV), the size of the aortic root, and left atrium. The assessment of left ventricular cardiac mass index (CMI g/m^2) was obtained according to the formula of Devereux [10]. Considering the regularity of the geometry of the left ventricular chamber of the athletes, the ejection fraction (EF) (%) was calculated according to the formula (LVEDd – LVESd/LVEDd), for which the volumes are substituted by the diameters. Body mass index was calculated as body mass (in kg)/height^2 (in m). From the five-chamber view, the possible presence of valve insufficiency was determined by continuous wave and color Doppler analysis. A possible valve insufficiency was described as the extent of the regurgitant flow on a 0–4+ scale, using the color-flow mapping method [7]. The analysis of diastolic function was performed in the presence of a stable HR calculated by R-R wave interval on the ECG and in three different but sequential measurements. It was calculated with Doppler measurements from transmitral flow including E wave A wave peak mitral velocities, isovolumetric relaxation and deceleration time and E/A ratio. All these variables were recorded from the LV 4 chamber view.

To complete the evaluation of diastolic function, Tissue Doppler Velocity (TDI) analysis was added. The TDI values, calculated as the average of those obtained from the portion of the inter ventricular septum and from the lateral wall of the LV at the basal segment close to the mitral valve, corresponded to the E_a and A_a parameters. The data obtained were then interpreted following the classification of the normal range for diastolic function, established for the absolute values in relation to age and also for the ratio derived from the values of transmitral flow with the TDI data [11].

Statistical analysis

All data are calculated and expressed as means ± standard deviation. Differences in mean values for the main parameters between BC and HW athletes and within the subjects of the same group were analyzed using analysis of variance. A probability value (p) of <0.05 was considered to be statistically significant; a value <0.001 was considered highly significant. Statistical power was tested by *post hoc* analysis.

Results

The women enrolled, both BC survivors and HW, were similar for their general characteristics. None of them were excluded from the study on clinical grounds. During the ECG examination at rest, none showed alterations of the atrium, ventricle and atrio-ventricular conduction, and none had alterations of the ventricle repolarization phase or Q wave T wave corrected (QTc) time duration compatible with pathological conditions. From echocardiography at rest, the EF was normal.

At the onset of the study, the two groups showed no echocardiographic differences in systolic function (Table 1).

Table 1. Echocardiographic parameters of BC and HW at 1 year and after 4 years of training.

Echocardiographic parameters	BC:55 1 year	BC:55 4 year	HW:36 1 year	HW:36 4 year
IVS (mm)	8.5 ± 0.9	9.00 ± 0.83	8.5 ± 0.7	8.89 ± 0.7
PW (mm)	8.5 ± 1.6	9.52 ± 4.92	8.5 ± 1.0	8.74 ± 0.7
LVEDd (mm)	45.3 ± 3.6	45.31 ± 3.61	45.7 ± 2.5	46.18 ± 2.5
LVESd (mm)	29.0 ± 2.4	30.18 ± 8.46	28.7 ± 2.8	28.66 ± 2.3
CMI (g/m^2)	84.6 ± 15.2	89.70 ± 16.20	88.12 ± 12.9	95.52 ± 15.1
EF %	64.1 ± 2.4	63.68 ± 3.76	65.18 ± 4.14	65.13 ± 3.3
LA (mm)	33.2 ± 2.9	33.89 ± 3.50	33.18 ± 3.39	33.47 ± 3.1
RV (mm)	21.7 ± 2.0	20.75 ± 1.9	21.33 ± 2.39	21.4 ± 2.7
E peck (cm/s)	69.5 ± 11.9	71.5 ± 12.2	77.90 ± 16.43[a]	73.05 ± 14.8
A peck (cm/s)	68.5 ± 15.1[b]	50 ± 14.1[b]	58.84 ± 13.80[a]	57.19 ± 16.8[a]
IVRT (ms)	83.6 ± 10.3[b]	73.62 ± 10.3[b]	78.33 ± 10.90[a]	78.59 ± 10.97
DTc (ms)	190 ± 19.9	190 ± 19.15	190.30 ± 30.60	197.18 ± 36.3
E/A ratio	1.05 ± 0.3	1.11 ± 0.3	1.36 ± 0.37[a]	1.37 ± 0.48[a]
E_a (cm/s)	9.3 ± 2[b]	11.89 ± 1.7[b]	11.45 ± 1.3[a]	11.53 ± 1.2
A_a (cm/s)	9.13 ± 1.8	9.56 ± 1.9	7.05 ± 1.56[a]	7.06 ± 1.5[a]
E/E_a ratio	7.98 ± 1.9	7.25 ± 1.9	6.57 ± 1.30[a]	6.57 ± 1.3[a]

[a]Values very statistically different ($p < 0.001$).
[b]Values statistically different ($p < 0.05$).
Abbreviations: BC = Breast cancer; CMI = Cardiac mass index; DTc = Deceleration time; E/A = E peck/A peck ratio; E_a velocity; A_a velocity; EF = Ejection fraction; HW = Healthy women; IVS = Inter ventricular septum; IVRT = Isovolumic relaxation time; LA = Left atrium; LVEDd = Left ventricle end diastolic diameter; LVESd = Left ventricle end systolic diameter; PW = Posterior wall; RV = Right ventricle.

Although within normal range, the parameters of diastolic function of the two groups were significantly different if compared singularly. At the onset of the study, the BC group, although still within the normal range if related to age (Table 1) [12], showed values compatible with a slight trend toward an initial diastolic dysfunction. This feature is particularly evident comparing the data with respect to the HW. The differences concerned the values obtained by Doppler transmitral flow assessment (E peck 69.5 ± 11.9 in BC versus 77.90 ± 16.43 for HW, A wave 68.5 ± 15.1 BC, 58.84 ± 13.80 HW; IVRT 83.6 ± 10.3 in BC versus 78.33 ± 10.90 in HW), with significant differences (Table 1). Also, the TDI parameters calculated (E_a cm/s, A_a cm/s, E/E_a ratio) showed significantly different values between BC and HW (Table 1). After 4 years of training, all the parameters of the diastolic function were significantly changed in the BC group. Overall, the values of diastolic function were significantly improved in the BC group, particularly with respect of the data of same group at the beginning of the study, but also compared to the HW group which trained for the same length of time. No modifications were otherwise observed in systolic function. *Post hoc* analysis assessed the efficacy of the regular physical activity in improving the diastolic function.

Color Doppler analysis showed a trivial mitral regurgitation and a tricuspid regurgitation +/++ with low velocity (no more than 2.5 msec) in 10 of 23 subjects of the BC group. The Color Doppler pattern was normal for the rest of the group. In group HW, color Doppler analysis showed no evidence of valve dysfunction. In 15 subjects, the degree of mitral and tricuspid valve regurgitation was trivial. None of the subjects investigated showed aortic valve dysfunction.

Regarding the ergometric test parameters, SBP and DBP at rest showed no statistical differences, while HR was lower in group BC. At the end of the effort test, maximal SBP and maximal HR calculated at the end of the effort, as well as the DP obtained from maximal SBP by maximal HR at peak effort, were similar.

After 4 years of physical training, all morphological parameters of systolic function did not show differences and were normal in both groups. Particularly, EF was similar in BC and HW subjects, while CMI (gr/m^2) was significantly higher in the HW group (95.52 ± 15.1 vs 89.70 ± 16.20, $p < 0.05$). As expected, the hemodynamic parameters were compatible with a higher training in HW: maximal HR (HW 75.36 ± 15.9 vs 67.62 ± 5.7 in BC) and DP (HW 23870 ± 3190 vs 22785.8 ± 276 for BC) were significantly higher in the HW group than in the BC group, after the training period. No participant developed dysrhythmias during ergometric test.

Discussion

Aerobic training has been proposed as a non-pharmacological intervention to modulate the adverse effects of cancer treatment and to improve the quality of life of the survivors [1]. Moderate physical exercise is generally cost-effective, feasible and well tolerated by all age groups [13,14]. Cancer patients are often well motivated to improve their health, and some of them can progressively plan to increase their physical activity [15]. Several studies have supported the role of exercise in the treatment of cancer patients [16,17]. The present study highlights, for the first time, the role of Dragon Boat training to maintain myocardial function in BC survivors who had undergone chemotherapy. In the present investigation, after 4 years of athletic training, in the group of BC survivors who practiced Dragon Boat training, all the cardiac parameters were within normal range and not different from the data observed in healthy active women. The cardiac function of BC survivors did indeed improve, and there were no pathologic cardiac events for the entire duration of the study.

These results underline the progressive improvement of diastolic function that is especially more evident in the group of BC compared with HW. This is the most relevant finding in this investigation and could have clinical implications in counselling post chemotherapy BC survivors. Diastolic function has been studied extensively with regard to cardiac health in both health and disease [18-20], indicating increased morbidity and mortality with lower diastolic function. The relatively low diastolic function of the BC group was increased significantly with regular moderate-to-vigorous physical activity, and training did not impact negatively on cardiac function. The initial impairment of diastolic function of the BC group provided a unique model to evaluate cardiac training adaptations. This is particularly evident from the diastolic parameters related to the pressure and volumes gradients among the myocardial chambers, but also from the fibers parameters, as TDI measurement show. The addition of a control group allowed to ascertain whether age-related changes in cardiac function were similar. In both groups, the training effects on myocardial function were beneficial, and more clinical significant in the BC group. Finally, this study spanned 4 years, considerably longer than most training studies.

The improvement in diastolic function is in fact evident by comparing the initial results with the final results of the study in BC group (Table 1), especially if they are compared with the modifications of the values in diastolic function in HW. The evaluation of diastolic function by the TDI parameters that evaluate the speed of the myocardial fibers further highlights these differences in both the comparison between BC with HW, and within the group of survivors of BC after 4 years of training.

Overall, the current literature indicates that supervised exercise therapy is safe and feasible, and associated with significant improvements in patients with early stage disease receiving conventional potentially cytotoxic adjuvant therapy [5,6]. Cardiotoxicity associated with BC treatment is a concern. Despite the recognized relevance of the myocardial systolic function in this field, the data obtained highlight the possible importance of the diastolic parameters following subjects such as cancer survivors who has undergone chemotherapy. High rates of cardiac dysfunction have been recorded in cancer patients treated with different types of therapy Other authors have also demonstrated the importance of aerobic training on physical function and quality of life in operable BC patients during or following chemotherapy [21-24].

Conclusion

Sports activity is normally evocate for preventing myocardial dysfunction. Most women exercise by walking, running, swimming or cycling or gym, but Dragon Boating can be safely practiced by BC survivors. It can be proposed for the potential positive effects on controlling upper limb edema and volume [3,4]. No negative impact was demonstrated in the presence of upper arm edema. Dragon Boat is a sport with moderate to high level of aerobic demands, and therefore with possible effects on myocardial function, but no data were available regarding the effects of this sport on the heart. The present investigation represents the first longitudinal clinical and instrumental study to verify some other possible positive effects of this sport in BC survivors. The investigation is extended to evaluate aspects other than cardiovascular function, such as the efficacy of Dragon Boat training on arm edema. There is some important information arising from the present investigation. In the first instance, it has been demonstrated that BC survivors with preserved LV function may practice sports. In addition, Dragon Boat training can improve cardiac performance. It seems that diastolic rather than systolic function is particularly influenced by regular sports activity, and therefore it is reasonable to propose Dragon Boat training in cancer survivors to prevent possible cardiac dysfunction due to chemotherapy.

The results obtained should not prompt to a blanket recommendation of Dragon Boat training in BC survivors, and some limitations are evident in this study. The sample was relatively small, and was not homogeneous with regard to chemotherapy received or type of BC. Second, we did not control for pre-study exercise history. Third, this group of BC survivors trained for Dragon Boat racing, and generalization to other forms of other type of exercise should be made with care.

Overall, in the present investigation, BC survivors were able to participate in vigorous upper body training, improve overall fitness and increase cardiac function with no adverse outcomes being reported. Upper body function is enhanced, and lymphedema is reduced in BC survivors following static resistance training [22]: this study demonstrated that similar effects are produced by Dragon Boat training.

As cancer survivors are encouraged to participate in physical activity post-treatment, it is important to recognize that the stress of physical activity, while in general beneficial, could potentially exacerbate sub-clinical pathologies. This study adds to the growing body of literature suggesting that regular physical activity is beneficial for cancer patients who do not present cardiac dysfunction. Further studies will be necessary to verify these findings, and use physical activity to attenuate or reverse chemotherapy-induced cardiomyopathy. Such studies will have to verify the impact of sport activity on BC survivors in reducing the sense of fatigue and preventing the negative effects of the cardiotoxic drugs used in chemotherapy treatment of BC patients.

Declaration of interest

The authors have no relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript. This includes employment, consultancies, honoraria, stock ownership or options, expert testimony, grants or patents received or pending, or royalties.

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