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Original Article

A remote, fully oriented personalized program of physical exercise for women in follow-up after breast cancer treatment improves body composition and physical fitness

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A R T I C L E I N F O

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Body weight changes
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A B S T R A C T

This study aimed to evaluate the efficacy of an individualized remote exercise program on the improvement of body composition and physical fitness of a heterogeneous group of patients who completed breast cancer treatment. This prospective study included 107 women aged 18 to 60, shortly after curative treatment for localized breast cancer, at the Erasto Gaertner Cancer Hospital (HEG) in Curitiba, PR, Brazil. Body composition, maximal oxygen consumption, and muscle resistance were evaluated after nine months of intervention while considering adherence to the program, level of physical activity, presence of binge eating disorder, tumor classification, and treatment type. Seventy-eight women (72.8%) adhered to the training program. Adherent participants showed significant changes in body mass ([-4.3 ± 3.6] kg; $p < 0.000\ 1$), body mass index ([-1.6 ± 1.5] kg·m^{-2}; $p < 0.000\ 1$), body fat (−3.4% ± 3.1%; $p < 0.000\ 1$), maximal oxygen consumption ([7.5 ± 2.0] ml·kg^{-1}·min^{-1}); $p < 0.000\ 1$), and abdominal resistance ([11.2 ± 2.8] reps; $p < 0.000\ 1$). In contrast, these variables did not change significantly in the non-adherent group. Among the adherent participants, those subclassified in the severe binge group showed a more noticeable reduction in body mass, body mass index, and body fat ($p < 0.05$) than those in the non-binge group. Individualized remotely-guided physical exercise programs can improve the body composition and physical fitness of women undergoing post-breast cancer surveillance, regardless of pathological history or treatment.

Introduction

Breast cancer is the world's most prevalent cancer, with 2.3 million women diagnosed and 685 thousand deaths globally in 2020.[1] Breast cancer risk is due to a combination of factors,[2] with obesity being strongly and positively associated with the disease. Overweight and obese women are more likely to develop breast cancer, recurrence, and mortality than women who maintain a healthy weight, especially after menopause.[3–5] Moreover, breast cancer patients tend to significantly gain body fat after diagnosis, which can be associated with endocrine therapy,[6] inability to exercise, and a diet high in saturated fats and sugar that are often driven by psychological factors such as depression, anxiety, and lack of motivation.[7]

Conversely, physical exercise by women diagnosed with breast cancer positively influences several aspects of the disease and quality of life. For example, a reduction in the recurrence and mortality risk from the disease at rates of 30% and 50% has been reported.[8–11] For patients who undergo chemotherapy and radiotherapy, regular physical exercise and a decrease in body mass index help to prevent complications in the cardiorespiratory, nervous, and endocrine systems.[12] However, it must be considered that some care must be taken when prescribing exercise routines for this group of patients. Persistent fatigue is frequently reported in patients on chemotherapy and radiotherapy, with skin and bone lesions in patients with metastasis and upper limb lymphedema following mastectomy and axillary lymph node dissection.[13]

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Abbreviations

1 RM	One-Repetition Maximum
ACSM	American College of Sports Medicine
ALND	Axillary Lymph Node Dissection
APA	American Psychiatric Association
BMI	Body Mass Index
BPM	COVID-19 Beats Per Minute SARS-CoV-2 Disease
ER	Estrogen Receptors
HEG	Erasto Gaertner Hospital
HER2	Human Epidermal Growth Factor Receptor 2
IPAQ	International Physical Activity Questionnaire
MPH	Miles per hour
PBES	Periodic Binge Eating Scale
PR	Progesterone Receptor
R-ABD	Abdominal Resistance
REPS	Repetitions
TNBC	Triple-Negative Breast Cancer
UICC	Union for International Cancer Control
$\dot{V}O_2$ max	Maximal Oxygen Consumption

According to the American Psychiatric Association (APA), patients who present characteristics of binge eating are evaluated with higher and earlier obesity levels compared to patients who do not have it, in addition to having low self-esteem and more failed attempts to try to lose weight, also presenting, for the most part, traces of depression. Within this context, the evaluation of binge eating prevalence rates becomes an important factor to consider in studies aimed at changes in habits and lifestyles linked to health.[14]

Although many studies have evaluated the impact of body composition on breast cancer prognosis and treatment,[15–18] few studies have explored the attainment of healthy body composition goals with regular physical activity.[8,19,20] This study evaluated the efficacy of an individualized remote exercise program in enhancing aerobic, muscular resistance, flexibility, and body composition of women who underwent treatment for breast cancer.

Materials and methods

Study design and population

A prospective cohort study was conducted between January 2016 and September 2019. It included women aged between 18 and 60 years within the 90 days of breast cancer curative oncological treatment (surgery, radiotherapy, and chemotherapy), and rehabilitation at the Erasto Gaertner Hospital (HEG), Curitiba, PR, Brazil, regardless of education level, socioeconomic status, and marital status. Exclusion criteria were incomplete medical record data, rehabilitation after breast cancer treatment longer than 90 days, and stage 4 patients. Subjects with mobility, metabolic, or uncontrolled cardiopulmonary diseases were also excluded due to the high degree of physical and functional impairment that the condition may cause. A total of 178 patients were initially screened (Fig. 1); 71 were excluded from the study because of mobility, metabolic, or uncontrolled cardiopulmonary diseases. The study population consisted thus of 107 participants who underwent body composition and physical capacity measurement in the physical therapy sector of the HEG just after enrollment and after six and nine months of follow-up. They scored at least 80 points on the Karnofsky Performance Index[21] at baseline and could carry out everyday activities without assistance. All participants were informed of the study's objectives, risks, and potential benefits, consenting to their participation by signing in duplicate the informed consent form, approved by the Research Ethics Committee of HEG under protocol number 2381057/2017.

Physical exercises were prescribed in the same sessions by the physical education professional assigned for this project to reduce data collection bias and inter-observational data differences. Seventy-eight patients followed the physical exercise prescriptions until the end of the study and were considered adherent, and those who stopped at any point were considered non-adherent ($n = 29$). All patients underwent body composition and physical fitness evaluations every three months.

Body composition measurement and determination of physical capacity

The participants resting heart rate (in BPM) was measured using an M430 M/l M-L Polar® brand frequency meter, and resting blood pressure (in mmHg) was measured following the American Heart Association

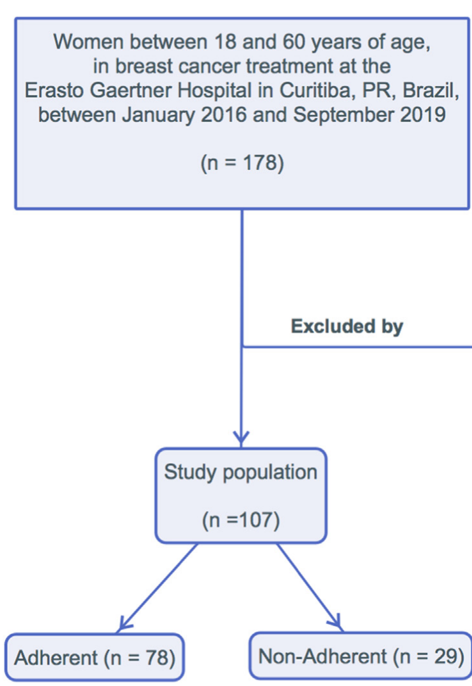

Fig. 1. Flowchart of patient's inclusion and exclusion criteria.

protocol,[22] using a Missouri® sphygmomanometer with a stethoscope. Tests were performed at 22 °C–25 °C, and care was taken concerning signs of fatigue or loss of motor coordination; always in communication with the patient to find out if she could continue. Weight (in kilogram) and height (in meters) were determined using a conventional scale (Filizola, M31, Brazil) and a portable stadiometer seal (Sanny, Standard-ES2030, Brazil). Bioimpedance was measured using four electrodes placed on the feet and hands (BioTetronic Tetrapolar Sanny, Professional-BIA-1010, Brazil). Body mass index (BMI) was calculated as BMI = weight (kg)/height (m^2). The cardiorespiratory capacity (in $ml \cdot kg^{-1} \cdot min^{-1}$) was estimated using the submaximal effort protocol, in a treadmill with increasing speed and inclination (Movement, R5i 127v, Brazil), following the modified Bruce protocol suggested by Ellestad (1984), recommended for special populations[13] (see Table Supplemental Digital Content 1). Maximal oxygen consumption ($\dot{V}O_2$ max) was estimated from the formula: (2.74 × time in min) + 8.03. The abdominal resistance was measured using the 1-Minute sit-up test (reps).[23]

Individualized exercise prescription and monitoring

From a pre-defined basis, the guidelines for exercise practice were adapted according to the treatment type for breast cancer, socioeconomic, geographic, physical limitations/skills, motivation, and the available time for managing the exercise routine. All prescriptions were individualized according to the American College of Sports Medicine (ACSM) recommendations and previous studies.[8,10,11,13,24]

After the initial evaluations, each patient underwent a face-to-face training session on the hospital premises to learn the correct execution of each exercise. Once each movement was considered acceptable to biomechanical and functional standards, the patient was considered ready to start remote monitoring. In case of learning difficulty or maintaining the motor pattern, another exercise that worked for the same muscle group or provided a similar physiological stimulus was chosen. Dialogue with the patients defined which objects they had at home that could be used as a load to perform localized muscle resistance exercises through functional adaptation since it was impossible to use weight machines. For example, a 500 ml bottle filled with water was used instead of dumbbells.

As presented in Table 1, the practice routine included simple and easy-to-perform exercises involving small muscle groups. Complex activities involving large muscle groups that required a higher level of preparation were also proposed according to the learning and execution capacity demonstrated by each patient. Sessions were organized into the initial phase (warm-up with joint mobility movements, lasting approximately 5 min), the main phase (walking, running, and localized muscle exercises), and a final phase (stretching), with the frequency adjusted to two to five times a week (see Table Supplementary Digital Content 2).

In face-to-face evaluations after six months of monitoring, patients who did not practice the exercises at least twice a week were considered non-adherent. All patients considered adherent after six months remained active after nine months. Adherent participants were monitored remotely using text messages or phone calls. Doubts about the correct execution of an exercise were solved through video calls, online videos, and images. The contacts also had a motivational purpose, keeping the patients committed to the program, especially for participants who needed specific care or attention that were contacted at least once a week. Those with more autonomy were contacted every two weeks.

Face-to-face monitoring was performed on the days of follow-up appointments. Information was raised concerning the execution of the prescribed exercises, any discomfort or inability to perform any of the activities, clarify doubts, make adjustments or change exercises, and reinforce the importance of remaining adherent to the practice of physical exercises to strengthen motivational aspects.

Table 1
List of exercises prescribed during the intervention.

Type of Activity	Exercise	Comments	Session Frequency	Volume/ Duration
Aerobic	Walk or Run	Control via heart rate reserve	3 to 5 weekly sessions	20–40 min per session
Localized Muscle Resistance	Abdominals	Varied exercises involving the trunk musculature in general	2 to 3 weekly sessions	2 to 5 sets of 5–50 reps
	Squat	Bodyweight and free weights	2 to 3 weekly sessions	2 to 4 sets of 6–30 reps
	Split Squat	Bodyweight and free weights	2 to 3 weekly sessions	2 to 4 sets of 6–30 reps
	Romanian Deadlift	Bodyweight and free weights	2 to 3 weekly sessions	2 to 4 sets of 6–30 reps
	Hip Thrust	Bodyweight and free weights	2 to 3 weekly sessions	2 to 4 sets of 6–30 reps
	Hip Abduction Exercises	Bodyweight and free weights	2 to 3 weekly sessions	2 to 4 sets of 6–30 reps
	Standing Calf	Bodyweight and free weights	2 to 3 weekly sessions	2 to 4 sets of 6–30 reps
	Shoulder Side/Front Raises	Free weights	2 to 3 weekly sessions	2 to 4 sets of 6–30 reps
	Barbell Curl	Free weights	2 to 3 weekly sessions	2 to 4 sets of 6–30 reps
	Alternating Curl	Free weights	2 to 3 weekly sessions	2 to 4 sets of 6–30 reps
	Forehead Triceps	Free weights	2 to 3 weekly sessions	2 to 4 sets of 6–30 reps
	Shrug	Free weights	2 to 3 weekly sessions	2 to 4 sets of 6–30 reps
	Bent-Over Lateral Raise	Free weights	2 to 3 weekly sessions	2 to 4 sets of 6–30 reps
	Superman Exercise	Bodyweight and free weights	2 to 3 weekly sessions	2 to 4 sets of 6–30 reps
Flexibility	Full Body Stretch	Active and passive stretches	3 to 5 weekly sessions	1 to 3 sets of 30 s to 1 min

Data collection

Socioeconomic data, date of the first diagnosis, molecular classification of the tumor, staging, histological type, axillary surgery (sentinel or axillary lymph node dissection), breast surgery (conserving or radical), radiotherapy, chemotherapy, and hormone therapy were collected from the medical records. Invasive breast carcinomas were classified according to molecular subtypes, based on the immunohistochemical assessment of estrogen receptors (ER), progesterone receptor (PR), expression of human epidermal growth factor receptor 2 (HER2), and the proliferation marker ki67, in subtypes: luminal A (RE+, RP+, HER2-, ki67 < 14%), luminal B (RE+, RP+, HER2-, ki67 ≥ 14%), HER2 overexpression (RE-, RP-, HER2+), and triple-negative (RE-, RP-, HER2-). Breast cancer staging was performed according to the UICC.[25]

The International Physical Activity Questionnaire (IPAQ)[26] was used to assess each patient's physical activity at baseline. Physical activities such as rest, sporting activities, and daily tasks like walking home to work were classified into three levels: Sedentary, Minimally Active, and Active. The eating prevalence rates were determined using the Periodic

Binge Eating Scale (PBES), validated by Duarte et al. (2015).[27] The functional capacity to perform independent daily tasks was assessed using the Karnofsky Performance Index[21] allowing the classification of patients according to functional capacity and demonstrating their independence in performing daily tasks without medical care.

Statistical analysis

Data analysis was performed using the SPSS program (version 25). Pearson's chi-square test was used to verify whether the frequencies of both adherent and non-adherent groups were statistically similar. The Kolmogorov-Smirnov test was used to assess the normality of the values obtained for the continuous variables: body mass, BMI, body fat% $\dot{V}O_2$ max, and abdominal resistance. The homogeneity of variance was verified using the test of Levene for the level of physical activity, presence of binge eating, tumor staging level, type of molecular classification of the tumor, submission to radiotherapy, and type of surgical procedure data. Repeated measures analysis was applied to evaluate the contrast of longitudinal changes at each time point between the two groups and within-group. If significance was not found, the mean variation after 6 or 9 months (Δ 0–6 and Δ 0–9) of each variable listed above was compared using the paired *t*-test. Means of Δ 0–9 within each factor (adherence, level of physical activity, presence of binge eating disorder, breast cancer staging, molecular classification of the tumor, submission to radiotherapy, and type of surgical procedure) were compared by analysis of variance (Type III), followed by Tukey's test when normality and homogeneity of variance were observed.

Results

The study initially included 107 women in follow-up after breast cancer treatment. Seventy-eight patients adhered to the individualized physical training program over nine months, while 29 participants discontinued the exercise program at any time in the first six months. The adherent and non-adherent participants had no significant differences in tumor classification and breast cancer treatment (Table 2). Most patients in both groups were treated for stage II Luminal B ductal carcinoma. As for treatment, these two groups were comparable in terms of having undergone mastectomy (> 40%) or quadrantectomy (> 55%), axillary lymph node dissection (ALND; > 55%), as well as chemo (> 48%) and radiotherapy (> 73%). Similarly, the participants in the two groups did not statistically differ in age, body composition, and physical fitness assessed at baseline (time 0) (Table 3). According to their reported physical activity by the IPAQ, most women were classified as minimally active in both groups. According to the PBES, non-adherent women were predominantly non-binging (48.3%) and moderate-binging (41.4%), while there was a more homogeneous distribution for the adherent participants. It is worth noting that for adherent patients, 34.6% were classified as having severe binging, compared to 10.34% of the non-adherent group.

The longitudinal changes between groups were analyzed to understand the changes over time better. As changes were non-significative, the mean variation of each variable after 6 or 9 months (Δ 0–6 and Δ 0–9) was compared (Table 4). Adherent patients showed significant changes in all variables in the first six months, which improved after nine months of training ($p\Delta < 0.000\ 1$). At the last evaluation, there was a significant reduction in body mass ([−4.38 ± 3.67] kg; $p < 0.000\ 1$), BMI ([−1.62 ± 1.53] kg·m^{-2}; $p < 0.000\ 1$), and fat percentage (−3.41% ± 3.17%; $p < 0.000\ 1$). In contrast, there were no significant changes in the non-adherent group: body mass ([2.83 ± 3.21] kg; $p = 0.827\ 7$), BMI ([1.16 ± 1.24] kg·m^{-2}; $p = 0.889\ 7$), and fat percentage ([1.77% ± 2.73%]; $p = 0.05$) in the period. For physical fitness, there was an overall statistically significant improvement in the analyzed variables, although more pronounced for the adherent group that showed $\dot{V}O_2$ max ([7.57 ± 2.06] ml·kg^{-1}·min^{-1}); $p < 0.000\ 1$), and R-ABD (11.26 ± 2.82; $p < 0.000\ 1$), versus $\dot{V}O_2$ max ([2.40 ± 1.75] ml·kg^{-1}·min^{-1}; $p = 0.009\ 44$), and R-ABD (4.58 ± 3.52; $p = 0.001\ 4$) in the non-adherent group.

Table 2
Breast cancer characteristics and treatments of adherents ($n = 78$) to the physical training program compared to the non-adherent participants ($n = 29$).

Variable	Description	Adherent n (%)	Non-Adherent n (%)	p-value*
Histological Type	Ducal Carcinoma	69 (88.46)	25 (86.20)	0.751
	Lobular Carcinoma	9 (11.54)	4 (13.80)	
Molecular Classification	Luminal A	14 (17.95)	5 (17.24)	
	Luminal B	45 (57.69)	15 (51.72)	
	HER2+	10 (12.82)	4 (13.79)	
	Triple-Negative	9 (11.54)	5 (17.24)	
Staging	1	17 (21.79)	3 (10.34)	0.357
	2	43 (55.13)	17 (58.62)	
	3	18 (23.08)	9 (31.03)	
Treatment Type	Chemotherapy	38 (48.72)	16 (55.17)	0.553
	Radiotherapy	57 (73.08)	24 (82.75)	0.299
Breast Surgery	Mastectomy	35 (44.87)	12 (41.37)	0.746
	Quadrantectomy	43 (55.13)	17 (58.62)	
Axillary Surgery	ALND	43 (55.13)	17 (58.62)	0.284
	Sentinel Node	24 (30.77)	11 (37.93)	
	None	11 (14.10)	1 (3.44)	

Note: ALND: Axillary Lymph Node Dissection. HER2: Human Epidermal Growth Factor Receptor 2. *Pearson's chi-square test ($p < 0.05$).

Body composition and physical fitness were further analyzed in adherent women, classified according to the IPAQ as sedentary, minimally active, and active. The IPAQ is a tool capable of evaluating a physical activity level, considering leisure time, sports practice, and daily tasks. Detailed analyses showed a progressive and statistically significant increase in $\dot{V}O_2$ max and abdominal resistance over 6 and 9 months for patients initially classified as sedentary (see Table Supplementary Digital content 3). Fig. 2 compares patients in each IPAQ classification, according to the average variable difference after nine months of exercise monitoring. It demonstrates that gain in abdominal resistance for the sedentary ($p = 0.19$) and minimally active group ($p = 0.007$) was significantly higher when compared with the active group.

The same variables were analyzed according to the binge eating scale (see Table, Supplementary Digital Content 4). There was a significant reduction in body mass ($p = 0.015$), BMI ($p = 0.39$), and body fat ($p = 0.12$) in the severe binging group than in the moderate group. Significant and progressive reductions in total body mass, body fat, and BMI were found in all groups, except for the percentage of body fat in non-binging patients ($p = 0.28$). When comparing changes in body composition among patients classified as normal, moderate, and severe binging, the differences between the non-binging and severe binging groups ($p < 0.001$) should also be noted for all variables (Fig. 3). There were no differences in changes in the physical capacity analysis, indicating the same level of improvement in all of them.

Analyses whether the tumor histological subtypes (Ductal × Lobular Carcinoma), molecular subtypes (Luminal A × Luminal B × HER2+ ×

Table 3
Comparison of age, body composition, and physical fitness, and binge score for adherents ($n = 78$) and non-adherents ($n = 29$) at baseline.

Quantitative Variable	Group	Average ± *SD*	Median (min-max)	*p*-value*
Age (years)	Adherent	43.8 ± 8.8	45 (24–74)	0.439
	Non-Adherent	45.2 ± 8.0	45 (25–59)	
Body Mass (kg)	Adherent	76.8 ± 15.6	76.5 (46.2–118.5)	0.334
	Non-Adherent	65.4 ± 14.5	63.1 (42.6–98.7)	
BMI (kg·m^{-2})	Adherent	28.3 ± 4.6	28.3 (17.2–41.9)	0.715
	Non-Adherent	25.1 ± 3.9	25.0 (18.6–33.8)	
Body Fat (%)	Adherent	31.8 ± 7.7	30.9 (19.7–52.6)	0.287
	Non-Adherent	27.9 ± 6.6	27.3 (17.8–45.5)	
$\dot{V}O_2$ max. (ml·kg^{-1}·min^{-1})	Adherent	21.6 ± 4.7	21.3 (10.3–29.9)	0.372
	Non-Adherent	22.9 ± 5.0	23.8 (13.2–31.2)	
R-Abd (Reps)	Adherent	23.4 ± 9.5	25.5 (4.0–39.0)	0.860
	Non-Adherent	19.9 ± 9.4	22.0 (3.0–39.0)	
Categorical Variable	**Categories**	**Adherent *n* (%)**	**Non-Adherent *n* (%)**	***p*-value****
Baseline IPAQ classification	Sedentary	15 (19.23)	6 (20.68)	0.492
	Minimally Active	44 (56.41)	19 (65.51)	
	Active	19 (24.35)	4 (13.79)	
Baseline PBES Score	Non-binging	29 (37.17)	14 (48.27)	0.05
	Moderate binging	22 (28.20)	12 (41.37)	
	Severe binging	27 (34.61)	3 (10.34)	

Note: *SD*: Standard Deviation; BMI: Body Mass Index; $\dot{V}O_2$ max: Maximal Oxygen Consumption; R-ABD: Abdominal Resistance, the highest number of repetitions (reps) in 1 min. IPAC: International Physical Activity Questionnaire; PBES: Periodic Binge Eating Scale Binge score. *Student *t*-test. and **Pearson's chi-square test ($p < 0.05$).

Triple negative), and stage (1 × 2 × 3) could influence gains in body composition and physical capacity seen in the adherent group, showed that no variable affected the physical activity program and results. Similarly, treatment including chemotherapy, radiotherapy, breast surgery (Mastectomy × Quadrantectomy), and axillary surgery (Axillary lymph node dissection × Sentinel Node × None) have no effect influencing the analyzed parameters.

Discussion

This study aimed to evaluate the effects of a remote prescription of physical exercise on the physical fitness and body composition of women who completed treatment for breast cancer. Total body mass, BMI, body fat% $\dot{V}O_2$ max, and abdominal resistance were compared over nine months of monitoring. Women who adhered to exercises showed significant changes in their body composition and physical fitness compared to non-adherents, regardless of the classification and clinical aspects of the disease. Before the intervention, physical activity was not a limiting factor for obtaining results, where both sedentary and active women showed significant results. However, those with severe binge eating showed significantly more prominent body composition variables than non-binging women.

Binge eating influences response to training, considering that patients with severe binging had higher initial body mass, BMI, and fat percentage values than other groups and obtained the best results in reducing these values. It is possible that the benefits of physical exercise on self-esteem, sleep-related problems, stress, and anxiety, have positively influenced the achievement of these results so that these patients have acquired a broader use of the intervention period, indicating the interference of psychological factors linked to excessive food intake and suggesting a contribution of physical exercise in this regard.[14,27–30]

During the intervention, there was an increase in localized muscle strength in the abdomen and an improvement in $\dot{V}O_2$ max, which also reflects an increase in muscle capacity.[31] In contrast to our study, which used exercises at a light and moderate intensity, Češeiko et al.[32] subjected patients on adjuvant treatment for breast cancer to sessions of strength exercises in lower limbs at high intensity, about 90% of 1RM twice a week for 12 weeks. After this period, they observed a significant increase in maximal muscle strength and improvements in fatigue and fitness levels, suggesting that high-intensity strength training, when well-planned and systematized, can be a great option not only to smoothen declines in strength that may occur in the treatment period but also to improve overall physical abilities. It is possible to attribute the gain in muscular capacity to neural stimulation due to the increased recruitment of motor units and their increased firing sequence.[33] Nevertheless, neural activation could be better observed using electromyography in future research.

Clinical aspects and types of treatment did not influence adherence to the program. More than that, none of these factors significantly influenced the results, demonstrating that any woman who experienced breast cancer can benefit from the practice of physical exercises. Our data indicate that a regular monitoring process, even if not face-to-face, significantly influences the practice of regular physical exercise, decreasing the impact of limitations.[9] The effectiveness of distance monitoring for patients who have undergone cancer treatment has been reinforced by Vallerand et al.[34] These authors conducted a follow-up for

Table 4
Body composition and physical fitness of adherents ($n = 78$) and non-adherent ($n = 29$) participants at baseline and after 6 and 9 months of the physical training program.

	Variable	0 Month	6 Months	Δ 0-6	9 Months	Δ 0-9	*p* Δ
Adherent *n* = 78 72.90%	Body Mass (kg)	76.8 ± 15.58	74.7 ± 14.20	−2.08 ± 2.06	72.4 ± 13.91	−4.38 ± 2.85	< 0.000 1
	BMI (kg·m^{-2})	28.3 ± 4.61	27.7 ± 4.32	−0.62 ± 0.78	26.7 ± 4.22	−1.62 ± 1.09	< 0.000 1
	Body Fat (%)	31.8 ± 7.74	29.6 ± 6.94	−2.13 ± 1.76	28.4 ± 6.42	−3.41 ± 2.53	< 0.000 1
	$\dot{V}O_2$ max (ml·kg^{-1}·min^{-1})	21.5 ± 4.66	25.8 ± 4.57	4.23 ± 1.55	29.1 ± 4.77	7.57 ± 2.06	< 0.000 1
	R-ABD (reps)	23.3 ± 9.50	30.4 ± 9.82	7.07 ± 2.28	34.65 ± 9.74	11.26 ± 2.82	< 0.000 1
Non-Adherent *n* = 29 27.10%	Body Mass (kg)	65.3 ± 14.47	68.1 ± 14.89	2.75 ± 1.44	68.2 ± 15.43	2.83 ± 2.51	0.827 7
	BMI (kg·m^{-2})	25.1 ± 3.92	26.2 ± 4.05	1.06 ± 0.59	26.3 ± 4.16	1.16 ± 0.95	0.889 7
	Body Fat (%)	27.9 ± 6.64	30.1 ± 7.26	2.25 ± 1.42	29.7 ± 7.46	1.77 ± 2.10	0.050 0
	$\dot{V}O_2$ max (ml·kg^{-1}·min^{-1})	22.9 ± 4.95	24.1 ± 4.99	1.26 ± 1.13	25.3 ± 5.66	2.40 ± 1.75	0.009 4
	R-ABD (reps)	19.9 ± 9.44	23.0 ± 11.49	3.13 ± 2.45	24.5 ± 12.57	4.58 ± 3.52	0.001 4

Note: Data shown as average ± standard deviation (*SD*). BMI: Body Mass Index. $\dot{V}O_2$ max: Maximal Oxygen Consumption. R-ABD: Abdominal Resistance, the highest number of repetitions (reps) in 1 min Δ 0–6: Value calculated as an assessment after six months minus the initial assessed value. Δ0–9: Value calculated as an assessment after nine months minus the first evaluation value. *p*Δ: paired *t*-test comparing Δ0–6 and Δ 0–9.

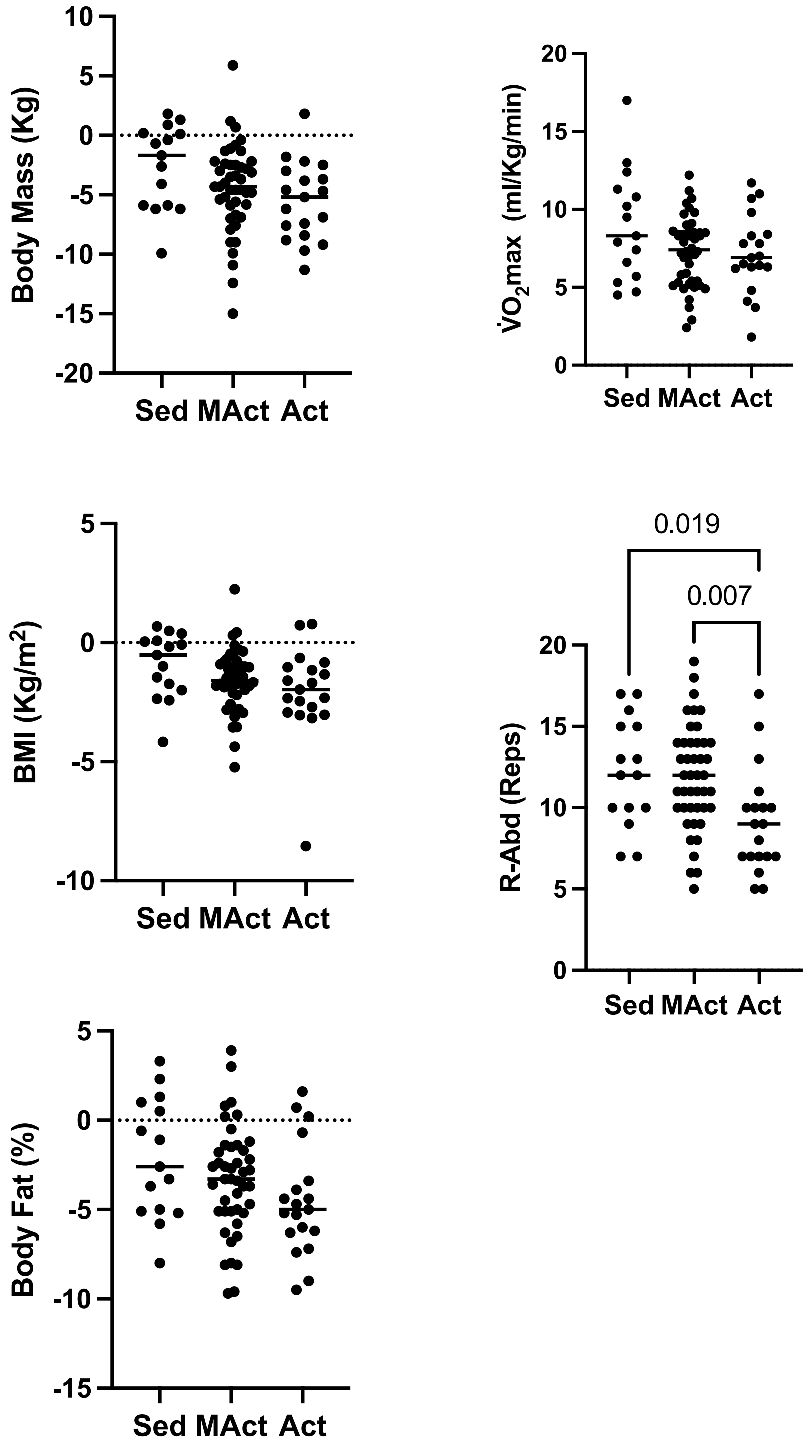

Fig. 2. Comparison of the changes in body composition and physical fitness in adherent participants classified according to the IPAC categorical score after nine months of training. Note: BMI: Body Mass Index. $\dot{V}O_2$ max: Maximal oxygen consumption. R-ABD: Abdominal Resistance, the highest number of repetitions (reps) in 1 min. Sed: sedentary, MAct: minimally active, Act: Active. IPAC: International Physical Activity Questionnaire.

physical exercise practice exclusively through phone calls and in-person physical assessments in 26 patients with hematological cancer. Adherence to the intervention was 93%, and retention was 100%, increasing the weekly rate of aerobic exercise by 218 min. Remote monitoring helps participants improve consciousness about their body and their responsibility for their lifestyle choices.

A limitation of our study was that the orientation sessions took place on the same day as the follow-up routines, which sometimes caused the patients to have long waiting times to be seen by the physician's staff and may have negatively influenced some results. Moreover, our study did not evaluate sedentary behavior, demarcated by the time the individual remains seated and with low energy expenditure, which may be associated with the risk of breast cancer mortality.[35,36] In other words, even if participants had acquired the habit of practicing regular physical

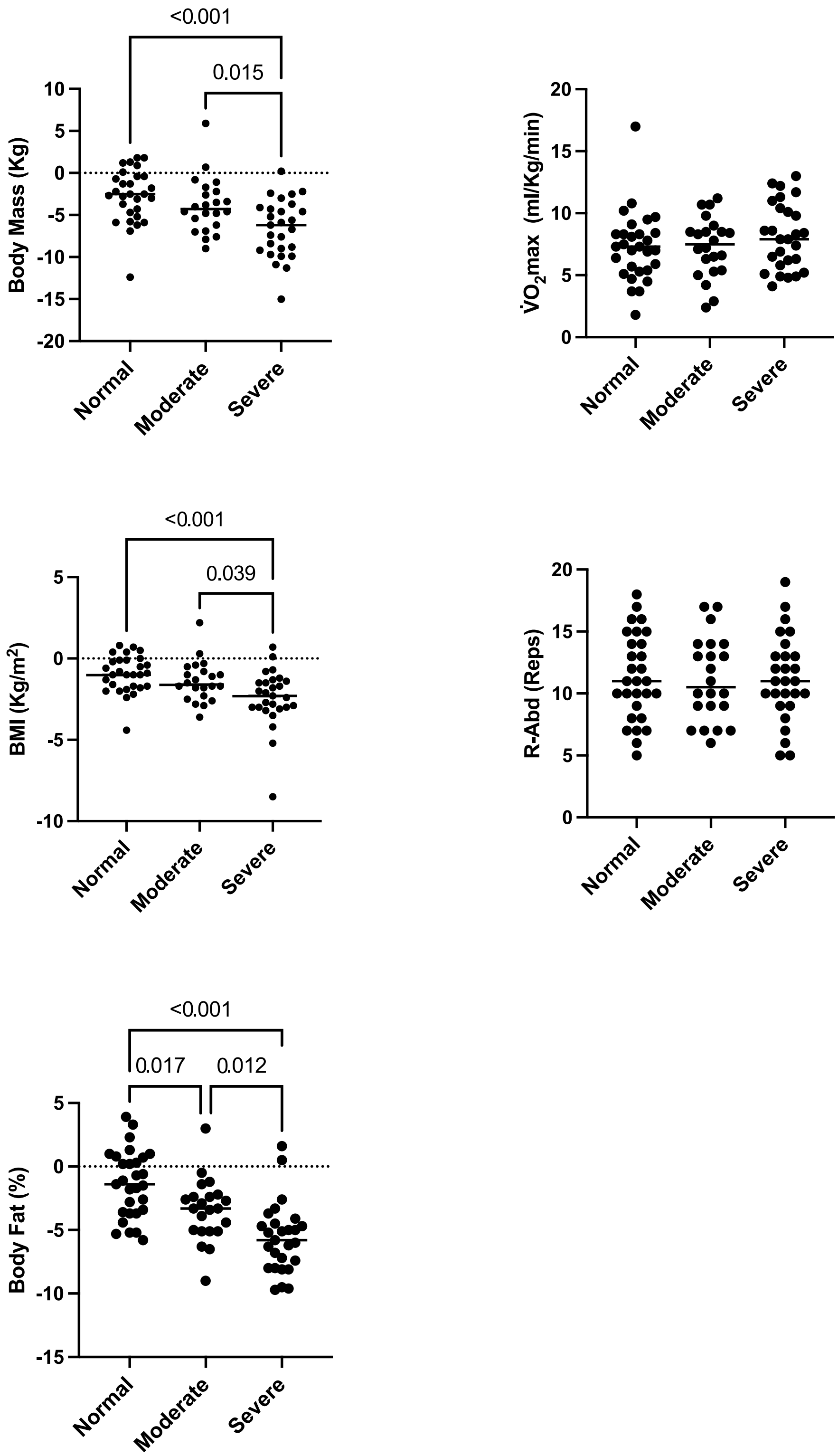

Fig. 3. Comparison of the changes in body composition and physical fitness in adherent participants classified according to the Binge eating scale categorical score after nine months of training. Note: BMI: Body Mass Index. $\dot{V}O_2$ max: Maximal oxygen consumption. R-ABD: Abdominal Resistance, the highest number of repetitions (reps) in 1 min. Normal: non-binging, Moderate: moderate binging, Severe: severe binging.

exercises during the intervention, time spent being sedentary daily may have influenced the results. Therefore, in addition to assessing the level of physical activity, it is also suggested to determine sedentary behavior to prescribe personalized exercises. Positively, we can highlight the relatively long intervention period.[37] with active participation in the proposed activities. The distance monitoring process and the methodology employed for prescribing the exercises, considering the women's well-being and comfort, have greatly influenced the study.

Conclusions

In this study, we presented a successful remote fitness monitoring program adapted for a cohort of women in follow-up after breast cancer curative treatment. We observed positive results from a methodology based on individualized training, following the recommendations of the American College of Sports Medicine (ACSM) for this population that allowed each participant to perform the activities according to their aptitudes, limitations, time availability, and the environment in which they live, regardless of the degree of impairment resulting from the disease. Whether they maintain exercise adherence after the program ended, especially during the SARS-CoV2 Disease (COVID-19) pandemic, and the impact on cancer outcomes should be addressed in the future.

Submission statement

All authors have read and agreed to the manuscript content. This manuscript has not been published and is not under consideration for publication elsewhere.

Ethical approval statement

All participants were informed of the study's objectives, risks, and potential benefits, consenting to their participation by signing in duplicate the informed consent form, approved by the Research Ethics Committee of Erasto Gaertner Hospital, Curitiba, PR, Brazil, under protocol number 2381057/2017.

Authors' contributions

Édipo Giovani França-Lara: Investigation, Writing- Original draft preparation. Saulo H Weber: statistical analysis supervision. Ricardo A Pinho: Writing - Review & Editing. José Claudio Casali-da-Rocha: Conceptualization, Investigation, Writing - Review & Editing. Selene Elifio-Esposito: Supervision, Writing - Review & Editing.

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Confict of interest

The authors have no conflict of interest to report.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.smhs.2023.03.005.

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