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Supervised Aerobic Dance Rehabilitation Improves Functional Capacity and Body Composition Across Obesity Strata in Breast Cancer Survivors Receiving Endocrine Therapy: A Four-Group Factorial Randomized Controlled Trial

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Abstract: Breast cancer survivors receiving adjuvant aromatase inhibitor therapy experience progressive deterioration in functional capacity and adverse body-composition changes, with obesity compounding these treatment-related sequelae. Whether supervised aerobic training produces comparable benefits across obesity strata in this population remains an open empirical question. Restoring functional capacity and preventing cancer-related disability are central goals of Physical and Rehabilitation Medicine, and supervised aerobic exercise is increasingly positioned as a structured rehabilitation strategy within survivorship care. This study aimed to (i) quantify training-induced changes in anthropometric and body-composition indices, (ii) evaluate functional aerobic capacity via the six-minute walk test (6MWT), and (iii) determine whether these responses differed between obese and non-obese participants. Sixty-eight women with hormone receptor-positive breast cancer receiving adjuvant letrozole were allocated in a 2×2 factorial randomized controlled trial (PACTR202512842728378) to four groups: experimental non-obese (ENOG, n=18), experimental obese (EOG, n=16), control non-obese (CNOG, n=16), and control obese (COG, n=18). Experimental participants completed 30 supervised aerobic dance sessions (50 min, three per week) over 10 weeks. Body composition was assessed by multi-frequency bioelectrical impedance analysis and functional capacity by the 6MWT. 6MWT distance improved substantially in both training groups (ENOG: +42.32 m; EOG: +49.45 m), while control groups showed negligible changes. Significant group-by-time interactions were observed for body mass and BMI. Importantly, the primary Time × Intervention × Obesity interaction was non-significant for 6MWT distance and fat mass, indicating that obesity status did not modify responsiveness to training. A 10-week supervised aerobic program substantially improves functional capacity and induces significant reductions in body mass and BMI in breast cancer survivors receiving aromatase inhibitor therapy, regardless of obesity status. These findings support the integration of supervised aerobic dance into cancer

rehabilitation and Physical and Rehabilitation Medicine care pathways as a functional restoration strategy for breast cancer survivors, irrespective of obesity status.

Keywords: aromatase inhibitor; aerobic dance; body composition; breast cancer; cancer rehabilitation; functional restoration; Physical and Rehabilitation Medicine; endocrine therapy; exercise oncology; functional capacity; obesity; randomized controlled trial; six-minute walk test

1. Introduction

Breast cancer (BC) is the most commonly diagnosed malignancy among women and remains a leading cause of cancer-related mortality worldwide **[1]**. In 2020, approximately 2.3 million new cases and 685,000 deaths were reported globally, representing 11.7% of all cancer diagnoses **[2]**. More recent GLOBOCAN 2022 data confirm that BC retains this position, with an estimated 2.4 million new cases and over 670,000 deaths recorded in 2022, accounting for approximately 12.5% of all incident cancers in women worldwide **[3]**. Breast cancer incidence has continued an upward trend, rising by approximately 1% annually between 2012 and 2021, a trend largely confined to localized-stage and hormone receptor-positive disease **[4]**. Beyond survival, many women face long-term challenges including cardiovascular disease, impaired physical function, and metabolic complications **[5,6]**. These risks are intensified by cancer treatments and further compounded by obesity and physical inactivity **[6]**. Approximately 5.4% of all cancers in women are attributable to excess body weight **[7]**, and women with obesity experience nearly twice the risk of developing BC compared with non-obese women **[8]**. Obesity increases both the onset and recurrence of BC, particularly in postmenopausal women **[9,10]**, primarily through mechanisms including increased adipose-derived oestrogen, elevated inflammatory cytokines (TNF-alpha, IL-6, IL-8), insulin resistance, and disrupted adipokine profiles characterized by higher leptin and lower adiponectin levels **[9,11,12]**. The oncogenic implications of this metabolic dysregulation extend beyond systemic effects to the tumour microenvironment itself: adipose tissue inflammation, hyperinsulinaemia, and elevated IGF-I collectively promote tumour cell proliferation, survival signalling, and treatment resistance in hormone receptor-positive disease **[13]**. These mechanisms underscore the importance of integrating obesity management, particularly exercise-based interventions, into survivorship care.

Structured exercise has emerged as an effective non-pharmacological strategy to reduce metabolic syndrome, improve circulating biomarkers, and mitigate obesity-related cardiovascular risks in BC survivors **[9]**. Regular physical activity is consistently associated with improved survival, reduced recurrence, enhanced physical function, psychological well-being, and overall quality of life **[14,15,16]**. Exercise interventions also consistently reduce key anthropometric markers including BMI, waist circumference, and body fat percentage **[17]**, with reductions in adiposity likely contributing to many of these health benefits **[18]**. Holmes and colleagues **[16]** demonstrated in a prospective cohort that women meeting physical activity guidelines after BC diagnosis had a 50% lower risk of BC mortality compared with sedentary counterparts. The updated American Cancer Society nutrition and physical activity guideline for cancer survivors, published in 2022, formally endorses aerobic exercise as a standard component of survivorship care and specifically recommends avoiding physical inactivity throughout the cancer care continuum **[19]**. Among exercise modalities, aerobic training is the most extensively studied in BC survivors **[20]**, with evidence from diverse interventional designs demonstrating improvements in cardiorespiratory fitness, metabolic regulation, adiposity, and insulin sensitivity **[11,14]**. The mechanistic basis for these benefits includes exercise-induced reductions in adipose tissue inflammation, improved peripheral insulin sensitivity

through GLUT-4 upregulation and AMP-kinase activation, decreased circulating IGF-I and IGFBP-3, and favourable modulation of the leptin-to-adiponectin ratio **[21,22]**. A 2022 meta-analysis specifically examining exercise effects in BC survivors confirmed significant reductions in inflammatory cytokines and IGF-system markers, providing direct biological validation for the role of aerobic training as a cancer-modifying intervention beyond its body composition effects **[23]**. Furthermore, aerobic exercise alleviates common cancer-related symptoms such as anxiety, depression, fatigue, and impaired quality of life **[24,25,26]**.

Aerobic dance represents a modality of particular relevance given its combination of well-established aerobic physiological benefits with the motivational and psychosocial advantages of group-based participation and musical accompaniment. A recent mixed-methods systematic review and meta-analysis confirmed that community dance programs are safe and feasible across all cancer types and stages, with demonstrated benefits for day-to-day functioning, fatigue management, and mental health in oncology populations **[27]**. Despite growing evidence, there remains a need to tailor interventions to specific subgroups, particularly obese BC survivors, by directly comparing their responses to those of non-obese individuals. Notably, women undergoing adjuvant hormone therapy represent a distinct and vulnerable subgroup. Long-term use of aromatase inhibitors or tamoxifen is associated with weight gain, increased fat mass, reduced cardiorespiratory fitness, insulin resistance, elevated systemic inflammation, and musculoskeletal symptoms including arthralgia that negatively affect treatment adherence **[9,12,28]**. These factors may further intensify cardiometabolic risk particularly in those with obesity. A critical gap concerns whether the functional and body-composition benefits of aerobic training are equivalently distributed across the obesity range in breast cancer survivors receiving active endocrine therapy. Most trials to date enrolled heterogeneous samples without prospective stratification by obesity status, and the three-way interaction among time, intervention, and obesity has rarely served as the primary inferential framework **[8,17,20]**. Evidence from the MENA region further highlights that post-chemotherapy cancer survivors face culturally specific barriers to physical activity that can limit the reach of exercise programs, making subgroup-specific evidence particularly important **[29]**. The six-minute walk test (6MWT) has been validated as a reliable, clinically practical, and prognostically meaningful measure of submaximal functional capacity across diverse patient populations **[30,31,32]**. A systematic review and meta-analysis specifically conducted in breast cancer survivors confirmed that exercise interventions improve 6MWT distance by an average of approximately 40 m, representing around 8% of baseline values, and that BMI independently predicts 6MWT performance in this population, directly justifying obesity status as a stratification variable in 6MWT-based exercise trials **[33]**. Fat mass is recognized as a primary endpoint in exercise oncology trials given its direct link to adverse prognosis **[7,8]**.

From a clinical perspective, determining whether obesity modifies responsiveness to exercise is essential. Obese breast cancer survivors often present with greater cardiometabolic risk, reduced functional capacity, and additional barriers to sustained physical activity. Therefore, understanding whether they respond differently to structured exercise is critical for tailoring rehabilitation strategies. If exercise benefits are attenuated, targeted or intensified interventions may be required; conversely, equivalent responses would support universal exercise prescription regardless of adiposity. For this reason, the Time × Intervention × Obesity interaction was defined as the primary inferential test.

The present four-group factorial randomized controlled trial therefore aimed to examine the effects of a 10-week supervised aerobic dance program on anthropometric, body-composition, and functional outcomes in breast cancer survivors receiving

adjuvant aromatase inhibitor therapy, with prospective stratification by obesity status. Three objectives guided the study: (i) to assess training-induced changes in body mass, BMI, fat mass, and related body-composition indices; (ii) to evaluate training effects on functional capacity as indexed by 6MWT distance; and (iii) to determine whether these responses differed between obese and non-obese participants. Based on existing evidence **[9,14,15]**, we hypothesized that obese survivors would show greater improvements in body composition, aerobic capacity, and metabolic markers, likely due to exercise-induced reductions in inflammation, enhanced insulin sensitivity, and modulation of adipokine profiles, which tend to be more dysregulated in individuals with obesity.

This trial is positioned within cancer rehabilitation, a recognized domain of Physical and Rehabilitation Medicine concerned with restoring function and limiting treatment-related disability in cancer survivors. Supervised aerobic dance is examined here as a structured rehabilitation modality, and 6MWT distance serves as a functional restoration outcome relevant to recovery pathways and disability management. This framing aligns with evidence that structured physical activity supports functional recovery in chronic disease **[56]**, and that supervised exercise rehabilitation after breast cancer treatment supports recovery **[57]**. Positioning the intervention in this way clarifies how obesity-stratified findings can guide individualized rehabilitation prescription in survivorship care.

2. Materials and Methods

2.1. Ethics Approval and Trial Registration

The study was conducted in full accordance with the Declaration of Helsinki and its subsequent amendments. Ethical approval was granted by two independent Human Research Ethics Committees: the Medical Oncology Department at Abderrahmane Mami Hospital, Ariana, Tunisia (approval number: N°46/2025), and the Ethics Committee of the High Institute of Sport and Physical Education of Kef, University of Jendouba (approval number: ISSEPK: 0040/2024). The approval granted by the University of Jendouba followed the institution's comprehensive digital framework for research ethics management, which integrates real-time verification and open-access documentation standards **[34]**. All procedures adhered to the highest ethical standards applicable to research in exercise science and oncology **[35]**. Written informed consent was obtained from all participants before any study procedure was initiated; given that all participants were adults, parental consent was not applicable. The trial was registered in the Pan African Clinical Trials Registry (PACTR) under the identifier PACTR202512842728378.

2.2. Experimental Design

Between September and December 2024, a 10-week four-group factorial randomized controlled trial was conducted to investigate the effects of supervised aerobic training in breast cancer patients undergoing adjuvant endocrine therapy. The study employed a 2×2 factorial design with two between-subjects factors: Intervention (supervised aerobic training vs. usual care) and Obesity Status (non-obese: BMI 18.5 to 29.9 kg/m² vs. obese: BMI 30.0 kg/m² or above), classified according to World Health Organization criteria **[36]**; and one within-subjects factor: Time (pre-intervention vs. post-intervention). Women with a BMI below 18.5 kg/m² (underweight) or above 42.0 kg/m² (severe obesity) were excluded to minimize health-related confounding and ensure participant safety.

Participants were first stratified by obesity status and then individually randomized within each stratum to either the training or usual-care control condition using

a computer-generated randomization list (1:1 allocation ratio) produced by a biostatistician independent of recruitment. Allocation was concealed using sequentially numbered, opaque, sealed envelopes opened only at the point of group assignment. Blinding of participants and exercise instructors was not possible given the nature of the intervention; however, all outcome assessors were blinded to group allocation throughout. This design yielded four study groups: experimental non-obese group (ENOG; BMI 21 to 28 kg/m²), experimental obese group (EOG; BMI 30 to 42 kg/m²), control non-obese group (CNOG; BMI 21 to 28 kg/m²), and control obese group (COG; BMI 30 to 42 kg/m²). Participants assigned to the experimental groups (ENOG and EOG) completed supervised aerobic sessions three times per week for 10 weeks, while those in the control groups (CNOG and COG) maintained their usual lifestyle. Baseline characteristics for all groups are presented in **Table 1**.

Table 1. Baseline Anthropometric and Body Composition Characteristics of Breast Cancer Patients, Stratified by Group Allocation.

Group	Age (years)	Body Mass (kg)	Height (cm)	BMI (kg/m²)	BF (%)	Lean Mass (kg)
ENOG	50.5 ± 6.2	64.31 ± 9.79	159.9 ± 5.3	25.00 ± 2.60	21.8 ± 6.2	20.1 ± 2.6
EOG	54.4 ± 6.4	92.50 ± 10.23	157.8 ± 2.9	37.12 ± 3.90	40.4 ± 5.8	25.5 ± 2.8
CNOG	50.6 ± 11.2	65.97 ± 9.78 [a]	160.2 ± 3.5	25.59 ± 2.80	23.2 ± 5.7	20.9 ± 3.1
COG	53.5 ± 6.2	89.65 ± 13.21	155.9 ± 4.9	36.70 ± 3.70	37.5 ± 7.5	24.9 ± 3.1

Values are mean ± standard deviation (SD). ENOG: experimental non-obese group; EOG: experimental obese group; CNOG: control non-obese group; COG: control obese group. BMI: body mass index; BF: body fat percentage. No statistically significant between-group differences were observed within the same obesity stratum at baseline, confirming successful stratified randomization.

2.3. Sample Size Calculation and Participants

An a priori sample size calculation was performed using G*Power (version 3.1.9.6; Universitat Dusseldorf, Germany) for a repeated-measures 2×2 factorial design, targeting the primary confirmatory three-way interaction term (Time × Intervention × Obesity); these data were subsequently analysed with the equivalent linear mixed-effects model described in Section 2.7. Using a two-sided significance threshold of alpha = 0.01 and a power of 90%, and adopting a conservative medium interaction effect size (Cohen's f = 0.27) **[30,37]** informed by the closest available exercise literature in clinically related populations, the required sample size was 72 participants. Accounting for anticipated dropout, 80 women were randomized; 68 completed post-intervention assessments and were included in the main analyses. Effect estimates are reported alongside confidence intervals to reflect the precision of observed effects.

The study enrolled a clinically homogeneous sample of postmenopausal women with histologically confirmed hormone receptor-positive breast cancer (HR+). All participants had undergone curative surgery (lumpectomy or mastectomy) followed by adjuvant chemotherapy based on anthracycline- and taxane-containing regimens. Patients with HER2-positive or triple-negative disease were excluded **[38]** to reduce biological and treatment-related heterogeneity. All included women were receiving the same adjuvant endocrine treatment, specifically daily letrozole (an aromatase inhibitor) prescribed for a minimum of five years.

A total of 320 women receiving adjuvant endocrine therapy were screened for eligibility at the Department of Medical Oncology, Abderrahmane Mami Hospital (Ariana Governorate, Tunisia). Of these, 240 were not randomized: 150 were ineligible at screening (e.g., BMI below 18.5 or above 42.0 kg/m², chronic respiratory/cardiac/neuromuscular conditions, HER2-positive or triple-negative tumors, or inability to attend three sessions per week), 52 declined participation after receiving full study information, and 38 faced logistical or administrative constraints. Ultimately, 80

women met all eligibility criteria and were randomized (n = 20 per group). Of the 80 randomized participants, 12 did not complete the study: in ENOG, 2 women did not finish the training protocol; in EOG, 4 participants were excluded due to incomplete post-intervention assessments (n=2) or insufficient adherence (n=2); in COG, 2 participants were lost to technical errors; and in CNOG, 4 were withdrawn due to unrelated medical issues (n=2) or failure to attend follow-up (n=2). The final analytical sample comprised 68 participants (ENOG n=18; EOG n=16; CNOG n=16; COG n=18). Participant flow is presented in **Figure 1.**

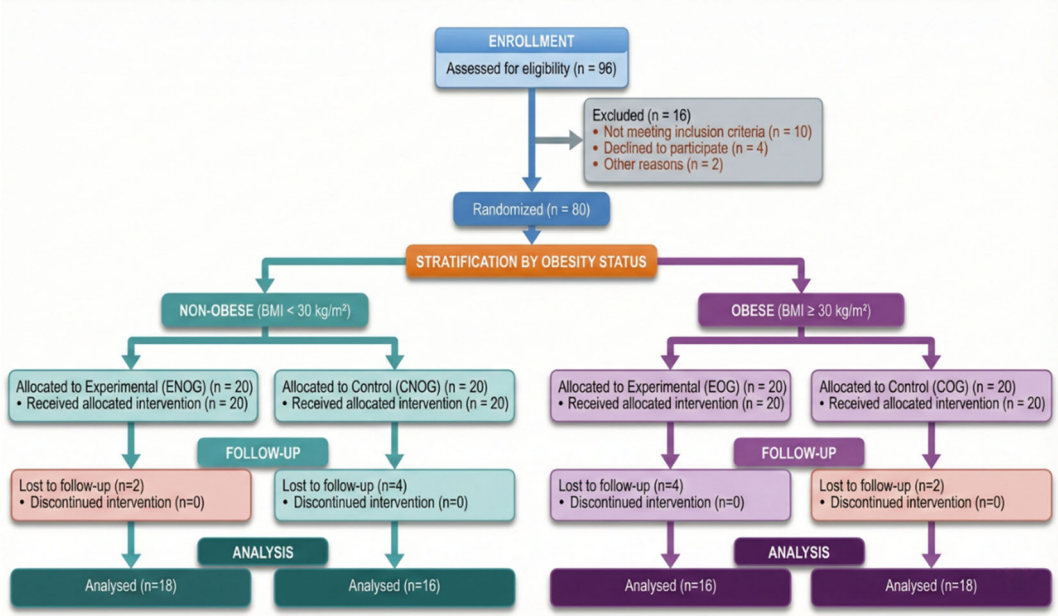

Figure 1. CONSORT flow diagram of participant recruitment, allocation, and retention in the 10-week supervised aerobic exercise intervention among breast cancer patients undergoing endocrine therapy. *BMI: body mass index; CNOG: control non-obese group; COG: control obese group; ENOG: experimental non-obese group; EOG: experimental obese group; n: number of participants.*

Inclusion criteria were: (1) women aged 18 to 65 years with non-metastatic breast cancer (stage I to IIIA, M0) diagnosed within the previous 6 to 24 months; (2) completion of chemotherapy and radiotherapy, with ongoing adjuvant endocrine therapy for five years or fewer; (3) absence of chronic respiratory, cardiac, or neuromuscular disease; (4) medical clearance for moderate-intensity supervised aerobic exercise; and (5) residence within Greater Tunis to facilitate attendance. Exclusion criteria included prior participation in structured exercise training, active smoking, engagement in non-supervised alternative therapies, or a history of another malignancy.

2.4. Exercise Training Intervention

Before enrollment, all participants underwent comprehensive medical screening conducted jointly by an oncologist and a cardiologist, including detailed medical history, physical examination, resting electrocardiogram, and any additional cardiopulmonary investigations warranted clinically. Physician clearance for moderate-intensity aerobic exercise was confirmed prior to allocation.

Exercise intensity was prescribed relative to age-predicted maximal heart rate (HRmax = 220 − age), with participants exercising within a target range of 60 to 75% HRmax, consistent with international guidelines for exercise prescription in oncology and obesity management **[24,44,45,46]**. This relative approach ensured equivalent physiological training stimulus across body-weight strata. Continuous heart-rate monitoring combined with post-session ratings of perceived exertion enabled real-

time adjustment of exercise intensity throughout the 10-week intervention, with participants beginning at the lower end of the prescribed range and progressing toward the upper end as adaptation occurred.

Participants in the experimental groups completed a structured, supervised aerobic exercise program (Aerobic Dance) over 10 weeks in a temperature-controlled indoor facility. The program followed a low-impact aerobics model originally described by Lance **[39]** and consisted of rhythmic, continuous movements performed in a group setting accompanied by music at a controlled tempo. This group-based format was deliberately selected to capitalize on the social cohesion and motivational properties characteristic of community dance programs, which have been systematically demonstrated to yield meaningful benefits for functioning, fatigue, and mental health in people living with cancer **[27,56]**. Training sessions were held three times per week (Monday, Wednesday, and Friday) between 09:00 and 10:00 a.m., for a total of 30 sessions. Each 50-minute session comprised a 15-minute warm-up incorporating dynamic stretching and progressive cardiovascular preparation, 30 minutes of continuous choreographed aerobic exercise adapted to individual functional capacity, and a 5-minute cool-down with active recovery stretching.

Heart rate was continuously recorded during each session using a Polar H10 chest strap paired with a Polar Vantage M2 watch (Polar Electro Oy, Kempele, Finland), with data transmitted via Bluetooth and archived via the Polar Flow software platform, enabling session-by-session verification of compliance with prescribed heart-rate zones. Ratings of perceived exertion were collected after each session using Borg's 6 to 20 scale **[40]**. Affective responses were assessed using Hardy and Rejeski's Feeling Scale **[41]**, administered at the 10-minute intra-session mark and immediately post-exercise, to monitor subjective tolerance and support adherence.

All sessions were supervised by a certified aerobics instructor with more than 10 years of experience in exercise prescription for cancer survivors. Choreographed routines were specifically designed to accommodate differences in BMI and individual functional limitations, creating an enjoyable and accessible environment. No interim fitness assessments were conducted during the intervention period; final assessments were performed at week 10 as scheduled. Participants were not instructed to modify physical activity outside the supervised sessions.

2.5. Control Group Procedures and Physical Activity Monitoring

Participants in both control conditions were instructed to maintain their habitual daily routines throughout the 10-week period and to refrain from any additional structured physical activity. Habitual activity was monitored at baseline and post-intervention using the short form of the International Physical Activity Questionnaire (IPAQ-SF), which has demonstrated acceptable reliability and validity in clinical populations **[42]**. Weekly telephone contact was maintained solely to support retention, monitor adherence to study instructions, and ensure data completeness, while minimizing any influence on habitual behavior. The same IPAQ-SF monitoring was applied to experimental participants to document activity outside supervised sessions, allowing observed adaptations to be attributed primarily to the prescribed aerobic stimulus.

2.6. Health and Performance Measurements

Health- and performance-related outcomes were assessed at two standardized time points: immediately before the start of the intervention (pre-intervention, week

0) and at completion of the 10-week program (post-intervention, week 10). All assessments were conducted in the morning between 08:00 and 10:00 a.m., following an overnight fast and bladder voiding, in a thermoneutral environment, by the same trained examiner using identical equipment at both time points.

2.6.1. Anthropometric and Body-Composition Outcomes

Body mass was measured to the nearest 0.1 kg using a calibrated digital scale (Seca 803; Seca GmbH, Hamburg, Germany), with participants wearing light clothing and no footwear. Height was measured to the nearest 0.5 cm using a wall-mounted stadiometer (Seca 206; Seca GmbH, Hamburg, Germany). BMI was computed as body mass in kilograms divided by height in metres squared.

Body composition was assessed by multi-frequency bioelectrical impedance analysis (BIA; Biody XpertZM3, Aminogram SAS) under strictly standardized conditions: overnight fast, bladder voiding, and abstinence from vigorous physical activity, alcohol, and caffeine for at least 24 hours prior to each assessment **[43]**. Fat mass (kg) and the manufacturer-defined fat-free/lean-mass construct were extracted directly from the device export using proprietary algorithms and served as the primary body-composition variables. Secondary device-derived outputs (resting metabolic rate, protein-related index, extracellular water percentage, intracellular water percentage) are reported descriptively and interpreted as estimated indicators rather than direct physiological measurements. Waist and hip circumferences were measured using a flexible non-elastic tape, and the waist-to-hip ratio (WHR) was calculated as an index of central adiposity and cardiometabolic risk.

2.6.2. Cardiovascular and Functional Capacity Outcomes

Resting heart rate (HRrest) was measured after 15 minutes of seated rest in a quiet, temperature-controlled room immediately before the 6MWT. Exercise heart rate (HRexercise) was defined as the mean heart rate recorded during the full six-minute walk. Heart-rate data were collected using validated wearable systems (Polar Team Pro version 3.0 and Polar V800 version 1.8.0; Polar Electro Oy, Kempele, Finland).

Functional aerobic capacity was assessed by the 6MWT administered in strict accordance with American Thoracic Society guidelines **[31]**, which has been validated as a reliable and prognostically meaningful measure in cancer survivor populations **[30,32,33]**. Participants were instructed to walk as far as possible in six minutes along a 30-metre indoor corridor marked at one-metre intervals. Standardized verbal encouragement was provided at one-minute intervals. Total distance walked was recorded in metres as the primary functional outcome.

2.7. Statistical Analysis

All outcomes were analyzed using linear mixed-effects models (LMM) implemented in R version 4.3.1 (R Core Team, Vienna, Austria) using the packages lme4, lmerTest, and emmeans. Fixed effects included Time (pre vs. post), Intervention (training vs. usual care), and Obesity Status (non-obese vs. obese), together with all two-way interactions (Time × Intervention, Time × Obesity, Intervention × Obesity) and the three-way interaction (Time × Intervention × Obesity). A random intercept for participant was included to model within-subject correlation and handle missing data under the missing-at-random assumption. Models were fitted by maximum likelihood; degrees of freedom were approximated using Satterthwaite's method.

The primary confirmatory hypothesis was tested by the Time × Intervention × Obesity interaction term. Fat mass and 6MWT distance were pre-specified as co-primary outcomes, with a two-sided significance threshold of alpha = 0.01 for all confirmatory inferences **[37]**. For secondary outcomes, findings are reported with 95%

confidence intervals and interpreted using alpha = 0.05 with explicit acknowledgment of their exploratory status. The marginal and conditional R^2 values were computed using the MuMIn package (Barton K, 2020, R package version 1.43.17) as indicators of fixed-effects and total model fit, respectively. Estimated marginal means (EMMs) were used for all planned pairwise contrasts, with Bonferroni correction applied within outcome family. Model assumptions were verified by inspection of residual diagnostic plots; no material violations were observed. Effect sizes were expressed as Cohen's d computed from model-derived standardized mean differences, classified as trivial (d < 0.20), small (0.20 to 0.49), medium (0.50 to 0.79), and large (0.80 and above) **[37]**.

2.8. AI Usage Statement

In preparing this manuscript, the authors used an AI language tool (ChatGPT model 5.2; version accessed December 2025) exclusively to improve the grammatical clarity and linguistic precision of selected passages. The tool contributed to no aspect of study design, data acquisition, statistical analysis, interpretation, or scientific reasoning. All intellectual content, data, conclusions, and scientific responsibility remain exclusively with the authors, in accordance with current guidance on responsible AI-assisted academic writing **[47,48]**.

3. Results

The primary confirmatory analysis showed no significant Time × Intervention × Obesity interaction for 6MWT distance or fat mass ($p > 0.05$), indicating that obesity status did not detectably modify responsiveness to supervised aerobic training. Functional and body-composition benefits were directionally comparable across obesity strata. A non-significant interaction reflects absence of a detected effect rather than proven equivalence, so this result is read as no evidence of effect modification within the available power, which is the central inferential finding of the factorial design.

All assessments were conducted under strictly standardized conditions including morning testing, overnight fasting, bladder voiding prior to measurement, and use of the same examiner and equipment at both time points. Complete pre- and post-intervention data for all outcomes across the four groups are presented in **Table 2**.

Table 2. Effects of 10 weeks of supervised aerobic dance training on body-composition and health-related outcomes.

Variable	Group	Baseline Mean (SD)	Post Mean (SD)	% Change	Main Effect of Group (beta, p, 95% CI)	Main Effect of Time (beta, p, 95% CI)	Group × Time Interaction (beta, p, 95% CI)
Body mass (kg)	CNOG	65.97 (9.78)	66.44 (10.13)	+0.7%	beta = 0.47, p=0.13, [−0.11, 1.05]	beta = −1.61, p=0.006, [−2.43, −0.80]	NS
	ENOG	64.31 (9.79)	63.17 (9.42)	−1.8%	beta = 23.68, p<0.001, [16.61, 30.75]	beta = 0.28, p=0.54, [−0.49, 1.06]	beta = 26.53, p<0.001, [19.29, 33.77]
	COG	89.65 (13.21)	90.40 (13.07)	+0.8%	NS		NS
	EOG	92.50 (10.23)	90.83 (9.87)	−1.8%	beta = −2.14, p<0.001, [−2.93, −1.34]		
BMI (kg/m²)	CNOG	25.59 (2.80)	25.76 (2.92)	+0.7%	beta = 0.17, p=0.139, [−0.06, 0.41]	NS	NS
	ENOG	25.00 (2.60)	24.60 (2.50)	−1.6%	beta = 11.11, p<0.001, [8.93, 13.29]	beta = −0.61, p=0.001, [−0.94, −0.29]	
	COG	36.70 (3.70)	36.90 (3.65)	+0.5%	beta = 11.54, p<0.001, [9.30, 13.77]	NS	NS
	EOG	37.12 (3.90)	36.50 (3.80)	−1.7%	beta = −0.83, p<0.001, [−1.15, −0.51]		
Fat Mass (kg)	CNOG	15.23 (4.51)	15.27 (4.60)	+0.3%	beta = 14.37, p<0.001, [10.22, 18.53]	beta = 0.23, p=0.142, [−0.07, 0.53]	NS
	ENOG	14.02 (4.10)	14.01 (4.05)	−0.04%	beta = 17.23, p<0.001, [12.97, 21.48]	beta = −0.48, p=0.029 *	

	COG	33.61 (7.20)	33.75 (7.30)	+0.4%	NS		NS
	EOG	37.42 (5.50)	37.41 (5.45)	−0.03%	beta = −0.90, p<0.001		
Muscle Mass (kg)	CNOG	19.7 (3.2)	19.5 (3.1)	−1.0%	beta = 0.13, p=0.83, [−0.04, 0.31]	beta = −0.03, p=0.006, [−0.05, −0.01]	NS
	ENOG	18.9 (2.4)	18.5 (2.6)	−2.1%	beta = 0.25, p=0.15, [0.07, 0.43]	beta = −0.01, p=0.21, [−0.03, 0.003]	NS
	COG	21.0 (2.6)	20.7 (2.7)	−1.4%	NS		NS
	EOG	22.2 (2.7)	21.9 (2.5)	−1.4%	NS		NS
RMR (kcal/day)	CNOG	1330.63 (122.87)	1328.38 (125.16)	−0.2%	beta = 75.93, p=0.031, [7.74, 144.12]	beta = 20.38, p<0.001, [14.67, 26.09]	NS
	ENOG	1289.06 (102.01)	1307.19 (99.29)	+1.4%	beta = 120.82, p=0.001, [50.35, 191.29]	beta = −0.25, p=0.93, [−5.97, 5.47]	NS
	COG	1406.55 (100.42)	1404.05 (104.92)	−0.2%	NS		NS
	EOG	1451.44 (95.21)	1451.61 (94.34)	+0.01%	NS		NS
Protein Index (g/kg/day)	CNOG	8.34 (0.94)	8.34 (1.00)	0.0%	beta = 1.621, p=0.0001, [0.829, 2.414]	beta = 0.315, p<0.001, [0.231, 0.399]	NS
	ENOG	7.81 (1.41)	8.13 (1.42)	+4.1%	beta = 2.256, p<0.001, [1.457, 3.055]	beta = −0.026, p=0.53, [−0.106, 0.054]	NS
	COG	9.96 (1.33)	9.93 (1.37)	−0.3%	NS		NS
	EOG	10.59 (1.03)	10.68 (1.09)	+0.9%	NS		NS
ECW (%)	CNOG	40.49 (3.13)	40.34 (3.11)	−0.4%	beta = 2.673, p=0.0002, [1.296, 4.051]	beta = 0.258, p=0.39, [−0.338, 0.854]	NS
	ENOG	40.66 (2.33)	40.76 (1.91)	+0.2%	beta = 2.948, p<0.001, [1.537, 4.359]	beta = −0.098, p=0.73, [−0.664, 0.468]	NS
	COG	43.16 (1.69)	42.91 (1.94)	−0.6%	NS		NS
	EOG	43.44 (1.14)	43.13 (0.98)	−0.7%	NS		NS
ICW (%)	CNOG	59.51 (3.13)	59.66 (3.11)	+0.3%	beta = −2.574, p=0.0004, [−3.940, −1.208]	beta = −0.257, p=0.40, [−0.843, 0.329]	NS
	ENOG	59.35 (2.33)	59.24 (1.91)	−0.2%	beta = −2.950, p<0.001, [−4.347, −1.554]	beta = 0.071, p=0.81, [−0.495, 0.637]	NS
	COG	56.94 (1.70)	57.16 (1.94)	+0.4%	NS		NS
	EOG	56.56 (1.14)	56.81 (0.93)	+0.4%	NS		NS
WHR	CNOG	0.55 (0.08)	0.56 (0.08)	+0.9%	beta = 0.239, p<0.001, [0.175, 0.302]	beta = −0.005, p=0.59, [−0.015, 0.005]	NS
	ENOG	0.53 (0.10)	0.53 (0.11)	0.0%	beta = 0.283, p<0.001, [0.220, 0.346]	beta = 0.007, p=0.15, [−0.002, 0.015]	NS
	COG	0.79 (0.11)	0.80 (0.12)	+1.6%	NS		NS
	EOG	0.83 (0.08)	0.83 (0.08)	0.0%	NS		NS
HR_rest (bpm)	CNOG	76.81 (5.41)	76.94 (6.01)	+0.2%	beta = −1.863, p=0.31, [−5.483, 1.757]	beta = −3.875, p<0.001, [−6.657, −1.093]	NS
	ENOG	75.25 (5.10)	71.50 (4.87)	−5.0%	beta = 5.132, p=0.008, [1.460, 8.803]	beta = 0.425, p=0.64, [−1.360, 2.210]	p<0.05
	COG	74.95 (6.81)	75.50 (6.94)	+0.7%	NS		NS
	EOG	81.94 (4.54)	78.39 (4.11)	−4.3%			p<0.05
HR_exercise (bpm)	CNOG	150.50 (16.25)	150.19 (13.95)	−0.2%	beta = −6.200, p=0.12, [−13.96, 1.56]	beta = −6.625, p=0.055, [−13.43, 0.18]	NS
	ENOG	158.94 (15.22)	152.00 (11.13)	−4.4%	beta = 17.167, p<0.001, [9.233, 25.100]	beta = 3.513, p=0.28, [−2.882, 9.908]	p<0.05
	COG	144.30 (10.56)	147.50 (10.29)	+2.2%	NS		NS
	EOG	167.67 (8.45)	160.89 (9.39)	−4.0%			p<0.05
6MWT (m)	CNOG	590.25 (42.23)	591.44 (42.51)	+0.2%	beta = −46.85, p=0.0003, [−71.61, −22.09]	beta = 41.13, p<0.001, [23.79, 58.46]	NS
	ENOG	585.31 (22.25)	627.63 (26.90)	+7.2%	beta = −3.31, p=0.80, [−28.60, 21.99]	beta = 48.26, p<0.001, [31.36, 65.16]	p<0.001
	COG	543.40 (42.86)	548.90 (54.38)	+1.0%	NS		NS
	EOG	586.94 (27.29)	636.39 (31.75)	+8.4%			p<0.001

Values are mean (SD). CNOG: control non-obese; COG: control with obesity; ENOG: experimental non-obese; EOG: experimental with obesity. BMI: body mass index; ECW: extracellular water; ICW: intracellular water; RMR: resting metabolic rate; WHR: waist-to-hip ratio; HRrest: resting heart rate; HRexercise: exercise heart rate during 6MWT; 6MWT: six-minute walk test. beta: estimated coefficient from the linear mixed-effects model; CI: confidence interval. NS: non-significant (p > 0.05). Significance levels: p<0.05 (exploratory secondary threshold); p<0.01 (confirmatory primary threshold); p<0.001. (*) Fat mass ENOG interaction beta=-0.48, p=0.029 reached the exploratory alpha = 0.05 threshold but not the pre-specified confirmatory alpha = 0.01 and is therefore treated as a directional trend. Primary outcomes (fat mass, 6MWT distance) were tested at alpha = 0.01. All secondary outcomes used alpha = 0.05. Three-way interaction (Time × Intervention × Obesity) was non-significant for all outcomes (p > 0.05). Lean mass reflects the manufacturer-defined fat-free/lean-mass construct exported by the BIA device.

3.1. Training Intensity and Session Adherence

Across all 30 supervised sessions, participants in the experimental groups maintained a mean RPE of 13.4 ± 1.2 on the Borg 6 to 20 scale, corresponding to perceived effort between "somewhat hard" and "hard," consistent with the prescribed moderate-intensity target range. No clinically meaningful differences in mean RPE were observed between obese and non-obese participants, indicating comparable relative exercise intensity across BMI categories throughout the intervention. Mean session adherence was 92% in both experimental groups (attended sessions divided by prescribed sessions, 30 total). No serious adverse events related to exercise were recorded.

3.2. Body Mass

Linear mixed-effects analyses revealed a significant main effect of group for body mass, reflecting the expected baseline differences between obesity strata (COG vs. CNOG: beta = 23.68, $p < 0.001$, 95% CI [16.61, 30.75]; EOG vs. CNOG: beta = 26.53, $p < 0.001$, 95% CI [19.29, 33.77]). The overall main effect of time was not statistically significant (beta = 0.47, $p = 0.129$, 95% CI [−0.11, 1.05]). Significant group-by-time interactions were observed in both experimental groups: body mass decreased significantly in ENOG (from 64.31 ± 9.79 to 63.17 ± 9.42 kg; beta = −1.61, $p = 0.006$, 95% CI [−2.43, −0.80]) and in EOG (from 92.50 ± 10.23 to 90.83 ± 9.87 kg; beta = −2.14, $p < 0.001$, 95% CI [−2.93, −1.34]), whereas no meaningful changes occurred in the control groups. The model accounted for 59.9% of variance through fixed effects (marginal $R^2 = 0.599$) and 99.8% through combined fixed and random effects (conditional $R^2 = 0.998$).

3.3. Body Mass Index

No significant overall main effect of time on BMI was observed (beta = 0.17, $p = 0.140$, 95% CI [−0.06, 0.40]). A strong main effect of group was identified, with BMI significantly higher in both obese groups compared with non-obese counterparts (COG vs. CNOG: beta = 11.11, $p < 0.001$, 95% CI [8.93, 13.29]; EOG vs. ENOG: beta = 11.54, $p < 0.001$, 95% CI [9.30, 13.77]). Significant group-by-time interactions were detected in both experimental groups: BMI decreased significantly in ENOG (from 25.00 ± 2.60 to 24.60 ± 2.50 kg/m²; beta = −0.61, $p = 0.001$, 95% CI [−0.94, −0.29]) and in EOG (from 37.12 ± 3.90 to 36.50 ± 3.80 kg/m²; beta = −0.83, $p < 0.001$, 95% CI [−1.15, −0.51]), while no meaningful changes occurred in the control groups. Fixed effects explained 75.9% of variance, with the full model accounting for 99.8%. Post-hoc contrasts confirmed that non-obese groups differed significantly from obese groups at all time points (all $p < 0.0001$, d = 3.22 to 3.58).

3.4. Fat Mass

Fat mass showed no significant overall main effect of time (beta = 0.23, $p = 0.142$, 95% CI [−0.07, 0.53]). Marked group differences reflected expected between-stratum separation (COG: beta = 14.37, $p < 0.001$, 95% CI [10.22, 18.53]; EOG: beta = 17.23, $p < 0.001$, 95% CI [12.97, 21.48]). Significant group-by-time interactions were detected in both experimental groups, indicating training-related attenuation of fat-mass trajectories relative to usual care: ENOG (beta = −0.48, $p = 0.029$) and EOG (beta = −0.90, $p < 0.001$). Although the ENOG interaction ($p = 0.029$) fell below the exploratory alpha threshold of 0.05, it did not meet the pre-specified confirmatory threshold of alpha = 0.01 and is therefore reported as a directional trend. The EOG interaction ($p < 0.001$) reached the confirmatory threshold. Post-hoc contrasts confirmed consistently higher fat-mass values in obese groups at both time points (all $p < 0.0001$, d = 2.26 to 2.87).

Changes in fat mass across groups are displayed in **Figure 2**. The model explained 63.7% of variance through fixed effects and 99.8% through the full model.

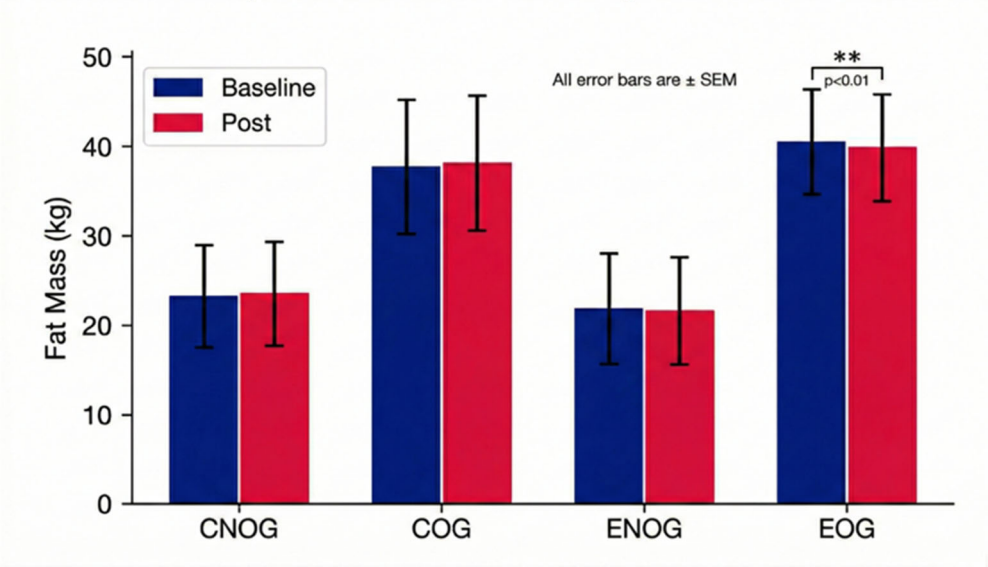

Figure 2. Comparison of fat mass (kg) at baseline and post-intervention among breast cancer survivors, stratified by obesity status and intervention allocation. *CNOG: control non-obese group; COG: control obese group; ENOG: experimental non-obese group; EOG: experimental obese group; kg: kilograms; SD: standard deviation; SEM: standard error of the mean.*

3.5. Muscle Mass

Muscle mass was consistently higher in obese participants than in non-obese counterparts at both time points. No meaningful changes in muscle mass were observed over the 10-week period in any group, consistent with the aerobic and non-hypertrophic nature of the training program.

3.6. Resting Metabolic Rate

Resting metabolic rate (RMR) was consistently higher in obese participants (reflecting greater body mass) and exhibited minimal change over the 10-week period across all groups. As RMR values were derived from proprietary BIA algorithms **[43, 57]**, they are interpreted as estimated indicators of metabolic status rather than direct calorimetric measurements, and are reported descriptively as secondary exploratory outcomes.

3.7. Protein Metabolism Index

The device-derived protein-related index followed a pattern similar to RMR, with consistently higher values in obese participants and only minimal changes over the intervention period in all groups. Given its algorithm-based derivation, this variable is reported descriptively only.

3.8. Extracellular and Intracellular Water

ECW% was consistently higher in obese than in non-obese participants at both assessment points (EOG vs. ENOG: beta = 2.948, $p < 0.001$, 95% CI [1.537, 4.359]; COG vs. CNOG: beta = 2.673, $p = 0.0002$, 95% CI [1.296, 4.051]), while ICW% showed the inverse pattern. Changes from baseline to post-intervention were small and not clinically meaningful in any group.

3.9. Cardiovascular Risk Index (WHR)

WHR was significantly higher in obese participants at both time points (COG vs. CNOG: beta = 0.239, $p < 0.001$, 95% CI [0.175, 0.302]; EOG vs. ENOG: beta = 0.283, p

< 0.001, 95% CI [0.220, 0.346]). Changes over 10 weeks were minimal across all groups, indicating that the aerobic-only program did not meaningfully modify central adiposity distribution within the study timeframe.

3.10. Resting Heart Rate

Resting heart rate declined in both experimental groups while control groups showed negligible change. ENOG decreased from 75.25 ± 5.10 to 71.50 ± 4.87 bpm (−5.0%; beta = 5.132, p = 0.008, 95% CI [1.460, 8.803]) and EOG from 81.94 ± 4.54 to 78.39 ± 4.11 bpm (−4.3%). Control groups changed by less than 1% in either direction, consistent with a training-induced improvement in cardiovascular efficiency.

3.11. Exercise Heart Rate

Mean heart rate during the 6MWT was consistently higher in obese than in non-obese participants at both time points (EOG vs. ENOG: beta = 17.167, p < 0.001, 95% CI [9.233, 25.100]). Both training groups showed reductions in exercise heart rate (ENOG: −4.4%; EOG: −4.0%), whereas control groups changed minimally (CNOG: −0.2%; COG: +2.2%), suggesting improved cardiovascular tolerance to submaximal effort.

3.12. Six-Minute Walk Test Distance

Six-minute walk distance improved markedly in both experimental groups, increasing from 585.31 ± 22.25 to 627.63 ± 26.90 m in ENOG (+42.32 m, +7.2%; d ≈ 1.71) and from 586.94 ± 27.29 to 636.39 ± 31.75 m in EOG (+49.45 m, +8.4%; d ≈ 1.67). These gains clearly exceeded the established MCID threshold (20–30 m), confirming clinical relevance at the group level, while control groups showed negligible changes (≤1%). The main effect of group was significant (beta = −46.85, p = 0.0003; 95% CI [−71.61, −22.09]). Importantly, the Time × Intervention × Obesity interaction was not statistically significant (p > 0.05), indicating equivalent responsiveness across obesity strata. Changes in 6MWT performance across groups are illustrated in **Figure 3**. Individual-level responder analyses could not be performed because individual change scores for the 6MWT were not available in the present dataset; clinical relevance was therefore judged at the group level against published MCID thresholds.

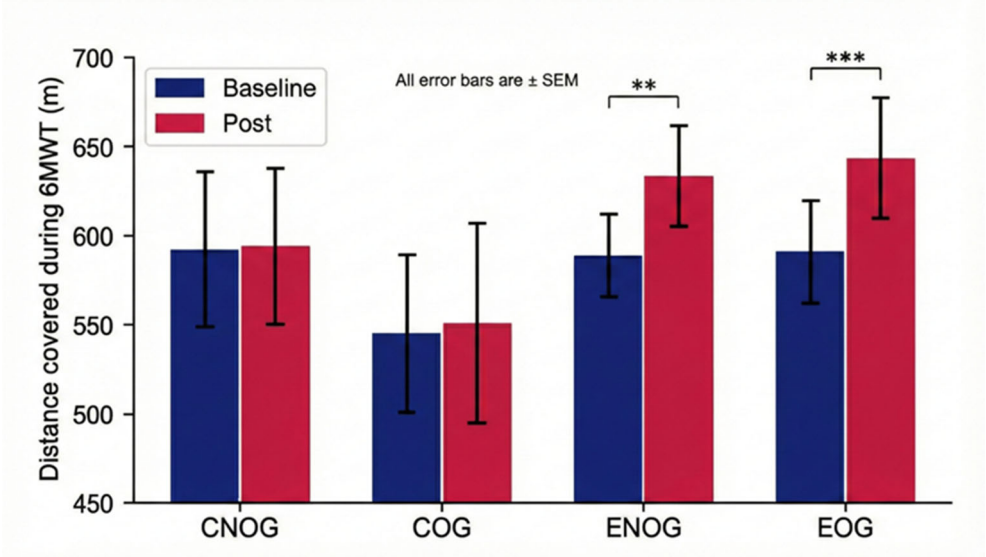

Figure 3. Comparison of functional aerobic capacity, measured by six-minute walk test (6MWT) distance, at baseline and post-intervention among breast cancer survivors stratified by obesity status and intervention allocation. 6MWT: six-minute walk test; *CNOG: control non-obese group; COG: control obese group; ENOG: experimental non-obese group; EOG: experimental obese group; m: metres; SD: standard deviation; SEM: standard error of the mean.*

4. Discussion

To ensure consistency with the a priori design, all confirmatory inferences in this study adhered to the pre-specified two-sided alpha = 0.01 threshold. The present study demonstrates that a 10-week supervised aerobic dance program produces meaningful improvements in functional walking capacity, alongside modest yet favorable changes in body-composition indices, in breast cancer survivors receiving adjuvant aromatase inhibitor therapy. Critically, these benefits were observed in both obese and non-obese participants, indicating that supervised aerobic exercise represents a feasible and effective component of supportive care across different levels of baseline adiposity. Contrary to the initial hypothesis, functional gains were comparable between obese and non-obese participants, suggesting that relative physiological responsiveness to aerobic training is preserved despite excess adiposity.

4.1. Functional Aerobic Capacity

The most clinically significant finding is the substantial improvement in 6MWT distance in both experimental groups: ENOG gained 42.32 m (+7.2%) and EOG gained 49.45 m (+8.4%), while matched control groups changed negligibly (+0.2% and +1.0%, respectively). Both gains considerably exceed the minimally clinically important difference of 20 to 30 m for the 6MWT in cancer populations **[30,31]**. The magnitude and direction of these improvements align closely with the pooled estimates from a systematic review and meta-analysis conducted specifically in breast cancer survivors, which reported an average exercise-induced improvement in 6MWT distance of approximately 40 m, representing around 8% of baseline values **[33]**. That same review established that BMI independently predicts 6MWT performance in breast cancer survivors, a finding that contextualizes the differential baseline walking distances observed between obesity strata in the present trial and underscores the methodological value of prospective obesity stratification in 6MWT-based exercise studies **[33]**. The absence of a significant three-way interaction indicates that obese breast cancer survivors derive functional benefits from supervised aerobic training that are proportionally equivalent to those of non-obese counterparts. Consequently, obesity should not be construed as a reason to withhold or deprioritize aerobic exercise referral in cancer survivorship programs. This finding is consistent with previous controlled trials in breast cancer survivors reporting comparable 6MWT improvements following 8 to 16 weeks of aerobic training **[8,17,20,49]**. High session adherence of 92% confirms that a musically enriched, instructor-supervised aerobic dance format is both feasible and well-tolerated in this population **[50,44]**. From a clinical standpoint, these findings directly reinforce current exercise oncology guidelines recommending at least 150 minutes of moderate-intensity aerobic activity per week as standard survivorship care **[24,44,45,46,19]**.

4.2. Body Mass and Body Mass Index

Statistically significant reductions in body mass were observed in both experimental groups (ENOG: −1.14 kg, −1.8%; EOG: −1.67 kg, −1.8%), while control participants showed negligible change. BMI followed the same pattern, decreasing by 0.40 kg/m² in ENOG and 0.62 kg/m² in EOG. These changes, modest in absolute magnitude, are clinically meaningful in the context of breast cancer survivorship: adiposity is a recognized modifiable determinant of disease recurrence and overall survival, and even small reductions in body mass reduce systemic metabolic and inflammatory burden **[7,8,10]**. The magnitude of change is consistent with findings from Lee and Lee **[50]**, who reported mean body mass reductions of 1.5 to 2.3 kg following 8

to 12 weeks of aerobic training in overweight or obese adults. Myers and colleagues **[51]** further demonstrated that structured aerobic exercise reduces fat mass and is only partially compensated through energy intake, supporting the assertion that aerobic training contributes to net energy balance independently of dietary changes. The proportionally equivalent BMI reductions in obese and non-obese groups confirm that the relative-intensity prescription did not systematically disadvantage obese participants. This is particularly relevant in the context of letrozole therapy, which is independently associated with progressive weight gain and increased adiposity over the treatment course, making exercise-induced attenuation of body mass gains clinically important even when absolute losses are modest **[9,12]**.

4.3. Fat Mass

Fat mass reductions in both experimental groups were numerically small but reflected statistically significant group-by-time interactions, indicating training-related attenuation of fat-mass accumulation relative to controls. The modest magnitude of fat-mass changes suggests that the primary benefit of the intervention may lie in preventing further adiposity increase rather than inducing substantial fat loss over a short duration. This pattern, in which aerobic exercise prevents gain rather than producing large absolute losses, has been consistently reported in supervised exercise trials in cancer survivors **[11,20]** and is mechanistically coherent. Aerobic training increases fat oxidation, improves peripheral insulin sensitivity through GLUT-4 upregulation and AMP-kinase activation, and suppresses adipokine-mediated lipogenesis through anti-inflammatory mechanisms **[21,22]**. A 2022 meta-analysis specifically examining the effects of exercise on inflammatory factors and the IGF system in breast cancer survivors confirmed significant reductions in circulating IL-6, TNF-alpha, and IGF-I following structured exercise programs, providing direct biological support for fat mass as a mechanistically relevant primary endpoint in this population **[23]**. The limited magnitude of absolute fat loss likely reflects the 10-week duration, the aerobic-only modality, and the moderate intensity prescription designed for clinical tolerability. Longer programs, combined aerobic-resistance protocols, or integrated dietary interventions may produce more appreciable reductions in fat mass **[50,51]**. The absence of a significant three-way interaction for fat mass confirms that the training-related attenuation of fat gain was equally present in obese and non-obese participants, reinforcing the conclusion that obesity does not modify the direction or relative magnitude of aerobic training benefit.

4.4. Cardiovascular Adaptations

Resting heart rate declined by approximately 5.0% in ENOG and 4.3% in EOG, while control groups showed negligible change. Exercise heart rate during the 6MWT was reduced by 4.4% in ENOG and 4.0% in EOG. These reductions reflect well-established cardiovascular adaptations to repeated moderate-intensity aerobic stimulation, including increased stroke volume, enhanced parasympathetic cardiac modulation, and improved peripheral oxygen extraction **[52]**. The magnitude of resting heart rate reduction aligns closely with findings from Schroeder and colleagues **[52]**, who reported comparable declines after 12 weeks of aerobic training in healthy middle-aged adults, underscoring the robustness of this adaptation across clinical populations. Aromatase inhibitor therapy is associated with altered cardiac autonomic balance **[9,12]**, and the present findings provide preliminary evidence that supervised aerobic exercise may partially counteract these treatment-related cardiovascular perturbations. WHR showed no meaningful change in any group, consistent with the established insensitivity of central fat distribution to aerobic-only programs of short duration in the absence of dietary intervention **[51]**.

4.5. Muscle Mass and Secondary Metabolic Outcomes

Muscle mass remained stable across all four groups, consistent with the aerobic and non-hypertrophic nature of the program. This finding aligns with previous research indicating that resistance or combined training modalities are required to elicit meaningful gains in lean mass in breast cancer survivors **[17,18,44,53]**. Aromatase inhibitors are associated with accelerated loss of lean mass through hypoestrogenic suppression of anabolic signalling **[9,12,28]**, and purely aerobic training is insufficient to offset these effects. Combined aerobic-resistance protocols should be incorporated into future survivorship programs targeting musculoskeletal preservation, as 12-month combined exercise interventions have been shown to prevent fat gain and increase lean mass in BC survivors receiving aromatase inhibitors **[53,46]**. Resting metabolic rate and protein-related indices were higher in obese participants and showed minimal change over time in all groups; these are reported descriptively only, given their dependence on proprietary BIA algorithms **[43]**.

4.6. Aerobic Dance as a Rehabilitation Intervention

The aerobic dance format employed in this trial warrants specific commentary beyond its generic classification as aerobic exercise. Dance-based physical activity occupies a distinctive niche in oncology rehabilitation by simultaneously delivering a cardiovascular training stimulus, social interaction, and musical engagement, properties that together address multiple dimensions of post-treatment well-being. A mixed-methods systematic review and meta-analysis of community dance interventions across cancer types and stages confirmed that this modality produces positive impacts on day-to-day task performance, fatigue levels, and mental health, and concluded that community dance classes are safe and feasible for people living with cancer at any stage of their illness or treatment **[27]**. A pilot randomized controlled trial of a ballroom dance intervention in cancer survivors (the RHYTHM trial) demonstrated feasibility and preliminary improvements in functional capacity indexed by 6MWT distance alongside quality-of-life benefits, providing direct evidence that dance-based formats can serve as viable vehicles for functional aerobic training in survivorship settings **[54]**. More recently, a randomized controlled trial of a 12-week home-based remote dance program in breast cancer patients confirmed significant improvements in EORTC quality-of-life summary scores and treatment-related fatigue, extending the evidence base for dance interventions to online delivery formats applicable in settings with limited in-person program access **[55]**.

Although previous studies report improvements in quality of life, fatigue, and mental health following exercise interventions, these outcomes were not directly measured in the present trial and therefore cannot be inferred from our results.

The 92% session adherence observed in the present trial is notable in this context and suggests that the group-format, music-accompanied aerobic dance structure effectively addressed the attitudinal and motivational barriers to exercise that remain pervasive in BC survivorship care. Future trials in this population should consider incorporating validated quality-of-life and affective outcomes alongside functional and body-composition measures to more completely characterize the multidimensional benefits of aerobic dance as a survivorship intervention.

4.7. Barriers to Physical Activity and Clinical Implications

Despite the strong evidence base for aerobic exercise in breast cancer survivorship, adherence to physical activity recommendations remains low in clinical practice, with barriers including fatigue **[25]**, musculoskeletal symptoms and aromatase

inhibitor-associated arthralgia **[28]**, and lack of access to supervised programs. Cancer-related fatigue is among the most prevalent and troublesome adverse effects experienced by patients during and after treatment, and a large meta-analysis confirmed that exercise is the most effective available intervention for its management, demonstrating superiority over pharmaceutical and psychological treatments **[25,26]**. Exercise has also been demonstrated to significantly reduce aromatase inhibitor-induced arthralgia, which is the most common reason for poor adherence to endocrine therapy, thereby indirectly supporting both treatment compliance and survivorship outcomes **[28]**. The updated American Cancer Society guideline for cancer survivors specifically recommends that oncology care providers counsel all survivors to avoid physical inactivity and to engage in structured aerobic exercise, regardless of obesity status or comorbidity burden **[19]**. In the MENA region specifically, post-chemotherapy cancer survivors face additional cultural and systemic barriers related to physical inactivity that underscore the importance of supervised, structured programs with built-in social support elements **[29]**. The present results reinforce the value of group-format, musically enriched aerobic programs as a strategy to overcome these barriers: 92% adherence in both obese and non-obese groups demonstrates that this modality is highly acceptable across the obesity range. These findings support strong clinical recommendations to refer obese breast cancer survivors to supervised aerobic programs with confidence that meaningful functional gains are achievable.

These findings also sit within the wider scope of Physical and Rehabilitation Medicine, where supervised exercise is one of several modalities used to restore function and manage cardiometabolic risk during survivorship. Rehabilitation approaches that target body composition and cardiorespiratory fitness, including structured exercise alongside adjunct balneological or hydrotherapy-based programs, share the common goal of functional recovery in cancer and chronic-disease populations **[59,61]**. Preserving musculoskeletal health remains a parallel rehabilitation priority, since endocrine therapy accelerates bone and lean-tissue loss and calls for targeted rehabilitation planning **[58]**. Characterizing body composition and cardiorespiratory fitness together, as done here, supports individualized rehabilitation prescription across metabolic phenotypes **[60]**.

4.8. Limitations

Several methodological limitations warrant consideration. First, body composition and metabolic indices were assessed by bioelectrical impedance analysis rather than dual-energy X-ray absorptiometry or computed tomography **[43]**, both of which provide greater measurement precision; small intervention-induced changes should therefore be interpreted with appropriate caution. Second, dietary intake was not systematically monitored or controlled, and unmeasured dietary changes may have contributed to inter-individual variability in body-composition outcomes. Third, cardiovascular fitness was characterized using submaximal indicators rather than directly measured maximal oxygen uptake, limiting conclusions regarding changes in cardiorespiratory capacity. Fourth, cancer-specific and inflammatory biomarkers, including adipokines, IGF-I, and circulating cytokines, were not assessed, precluding mechanistic interpretation of observed changes and representing a notable gap given the established importance of these pathways in exercise-mediated BC prognosis **[13,23]**. Fifth, all participants were postmenopausal women with HR-positive breast cancer receiving letrozole, limiting generalizability to other cancer subtypes or treatment regimens. Sixth, the 10-week duration may have been insufficient to elicit maximal adaptations in outcomes with longer physiological latency. Future trials

should incorporate dual-energy X-ray absorptiometry, maximal aerobic testing, direct biomarker panels including adipokines and inflammatory markers, dietary co-monitoring, and longer follow-up to provide a more complete characterization of aerobic training effects across the obesity range in breast cancer survivors on endocrine therapy.

Finally, individual responder profiles and MCID-based responder rates for the 6MWT were not available for the present revision; consequently, clinical meaningfulness was interpreted at the aggregate group level using mean changes relative to published MCID thresholds. Future studies should prospectively report individual responder distributions, non-responder proportions, and number-needed-to-treat estimates.

5. Conclusions

This four-group factorial randomized controlled trial shows that 10 weeks of supervised aerobic dance meaningfully improves 6MWT performance in breast cancer survivors receiving aromatase inhibitor therapy, with gains exceeding accepted MCID thresholds in both obese and non-obese participants. Body mass, BMI, and heart-rate indices also improved modestly in the training groups, whereas control groups changed minimally. The non-significant Time × Intervention × Obesity interaction is the central clinical message: obesity did not attenuate the benefits of relative-intensity supervised aerobic training. Accordingly, obese breast cancer survivors should be actively referred to supervised aerobic exercise rather than considered less responsive candidates. Future trials should extend follow-up, combine aerobic and resistance training, monitor diet, include direct cardiometabolic and inflammatory biomarkers, and report individual responder rates to refine exercise prescription across metabolic phenotypes. Embedding supervised aerobic dance within cancer rehabilitation and Physical and Rehabilitation Medicine care pathways offers a practical route to functional restoration and disability prevention for breast cancer survivors receiving endocrine therapy, irrespective of obesity status.

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Institutional Review Board Statement: This study was conducted in compliance with the ethical standards of two Human Research Ethics Committees: the Medical Oncology Department of Abderrahmane Mami Hospital, Ariana, Tunisia (approval no. N°46/2025), and the Ethics Committee of the High Institute of Sport and Physical Education of Kef, University of Jendouba (approval no. ISSEPK: 0040/2024). All procedures adhered to the Declaration of Helsinki. Written informed consent was obtained from all participants prior to their inclusion. The trial was registered in the Pan African Clinical Trials Registry (PACTR) under identifier PACTR202512842728378.

Informed Consent Statement: Written informed consent was obtained from all participants prior to study inclusion. All participants consented to anonymous use of their data for research purposes and for publication.

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