Reclaiming Wellness: A Comparative Study of High-Intensity Interval Training and Low-Calorie Diets in Optimizing Body Composition and Cardiorespiratory Parameters for Breast Cancer Survivors

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Abstract

Background: *Breast cancer (BC) is a frequent malignancy with elevated mortality rates among females. Conventional BC treatments may entail negative impacts on BC survivors. The aim to compare the effectiveness of high-intensity interval training (HIIT) and hypo-caloric diet (HCL) on body composition, and cardiorespiratory fitness (CRF), alongside quality of life (QoL) in patients who underwent a radical mastectomy.*

Patients and methods*: This randomized, comparative, double-blinded enrolled 60 female post-radical mastectomy participants aged 40–60 years old from the Hormonal Therapy Outpatient Clinic at Meet-Ghmmr Oncology Center, Egypt, from June to October 2022. The participants were randomly and equally (N= 30) allocated into Exercise group (A), which received HIIT (5 days/week, 30 min/session), and Diet group (B), which received a hypo-caloric low-carb diet. Our study evaluated weight, BMI, WC, fat and lean mass, heart rate (HR), and maximal oxygen uptake (VO_2 max) alongside QoL by the European Organization for Research and Treatment of Cancer (EORTC QOL-C30) Questionnaire at baseline and after eight weeks.*

Result: *The study revealed a significant enhancement from pre- to post-treatment in all parameters in both groups, with significant differences in BMI, HR, fat mass, and EORTC QOL-C30 favoring the diet group. Moreover, the exercise group has a statistically superior disparity in VO_2 max.*

Conclusion*: HCL has a beneficial impact on body composition and QoL. Meanwhile, HIIT enhanced CRF for patients with post-radical mastectomy.*

Keywords*: Low-carb Diet; HIIT; fat mass; lean mass; Radical Mastectomy; Aerobic exercise; maximum oxygen consumption.*

INTRODUCTION

Breast cancer (BC) is a prevalent type of cancer globally, affecting women in all countries and age groups following puberty, with higher incidence rates in older individuals [1]. In Egypt, BC has a rate of 32% between all types of cancers [2]. Although BC and its treatment strategies (mastectomy, chemo/radiotherapy, as well as targeted and endocrine therapies) [3] possess a goal of reducing mortality [4], they can develop some common side effects, including fatigue, depression, bone loss, reduced muscular strength and aerobic capacity, heightened weight gain, and eventually, hindered quality of life (QoL) [5]. Additionally, body image is negatively affected, especially for women with mastectomies [6]. The BC survivors are thought to have a higher incidence of dyslipidemia (DLP), especially post-chemotherapy [7]. Accordingly, lipid monitoring, DLP prevention, and a planned intervention are essential points for healthcare professionals to improve [8].

Cancer survivors ought to endeavor to attain an optimal body weight by carefully managing their calorie consumption and engaging in regular physical activity (PA) [9]. Obesity and metabolic syndrome may increase recurrence risk or reduce survival rates in patients having BC and gastric cancer [10]. BC survivors are advised to maintain a healthy weight (Body mass index (BMI) of 18.5–25 kg/m2) besides adopting a healthy lifestyle by engaging in regular PA, following a diet consisting of vegetables, fruits, and whole grains, and limiting the intake of saturated fat and red meat [11].

Engaging in consistent PA is related to lower BC occurrence and reappearance [12]. Furthermore, diverse forms of PA have demonstrated efficacy in enhancing the cardiorespiratory capacity of BC survivors, thus diminishing the adverse effects associated with cancer therapy [13]. Numerous research has explored the impact of High-Intensity Interval Training (HIIT) on cardiorespiratory fitness (CRF) and QoL among BC survivors, as well as the effects of dietary interventions [14]. Thus, we aim to compare the efficacy of both interventions in body weight, fat and lean mass, CRF, and overall QoL.

MATERIALS AND METHODS

This randomized, comparative, double-blinded trial was conducted from June to October 2022 to compare the effectiveness of HIIT and hypo-caloric diet (HCL) on body composition, waist circumference (WC), BMI, CRF, alongside QoL in patients who underwent a radical mastectomy. Sixty BC survivors meeting specific eligibility criteria were purposefully selected from the Hormonal Therapy Outpatient Clinic at the Meet-Ghmmr Oncology Center in Egypt and randomly allocated into two equal groups (N=30). The Cairo University's Academic and Ethical Council authorized this study with the approval number of (P.T.REC/012/004286). All participants in this trial signed informed consent. Our study followed the International Medical Association's rule of ethics for human studies, the Helsinki Declaration.

Inclusion criteria were the patients had the same type of surgery (Modified Radical Mastectomy), the study was started three months after ending their chemotherapy and/or radiotherapy, and they were undergoing hormonal therapy without signs of recurrence or advanced disease, cancer grades of I–III, patients aged 40–60 years old, BMI of 25–34.9 kg/m2. The

participants had been inactive, engaging in <150 min/week of moderate-intensity exercise for a minimum of six months.

Exclusion criteria were the patient had metastasis, uncontrolled hypertension, advanced diabetes mellitus, immunodeficiency, thyroid or endocrine diseases, serious orthopedic, neurological, or cardiac disorders that affect their performance and impaired movement, cognitive, psychiatric disorders, and unstable cardiovascular conditions (Fig. 1).

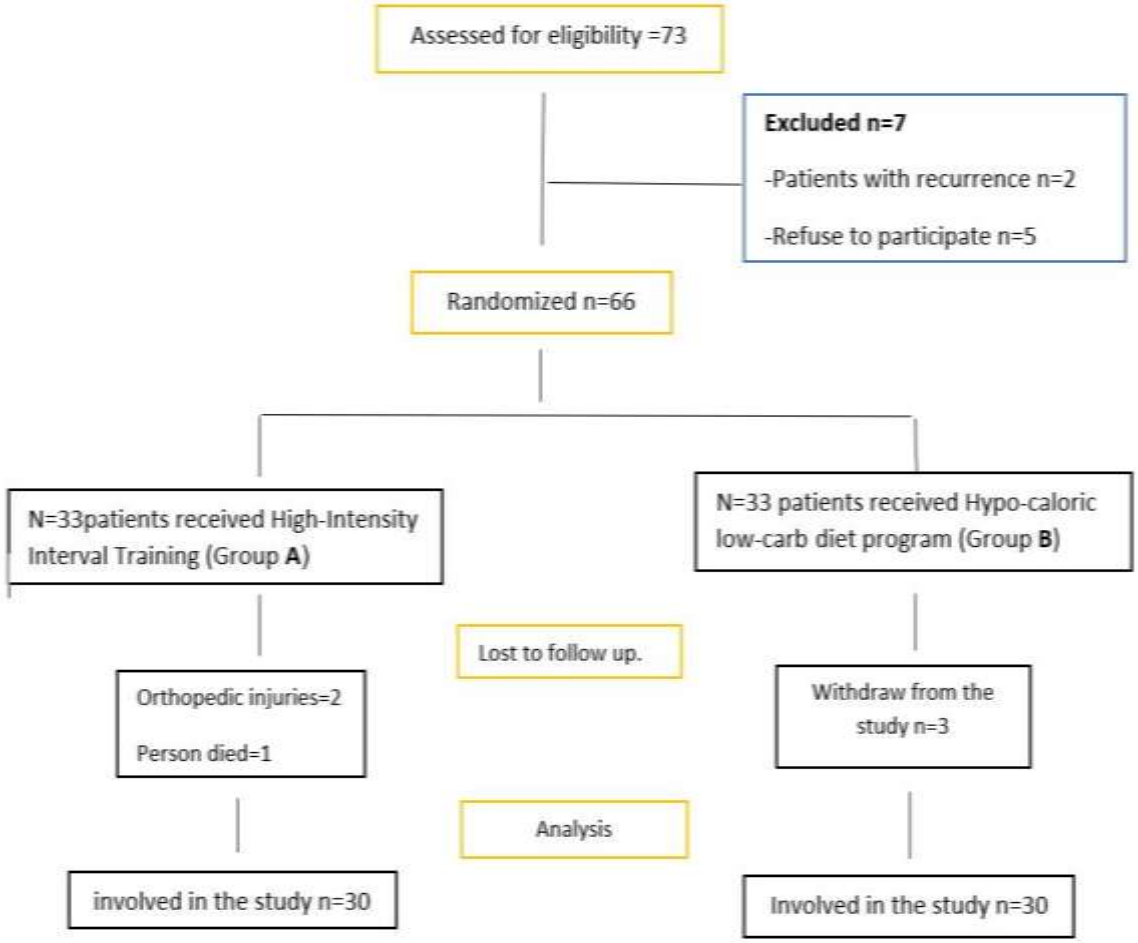

Fig. 1 The study's Consort diagram

Procedures

High-Intensity Interval Training HIIT

Each participant enrolled in the HIIT program attended five sessions/ week for eight weeks. The total time of the exercise session was 30 min, commencing with a 5-minute warm-up period consisting of walking on a treadmill (Power max treadmill TDA-350) to gradually elevate the heart rate (HR) to 50%–60% of the maximum HR (HR max). Followed by the main phase of the session. This phase comprised 3-minute intervals of high-intensity exercise, which progressively increased, aiming to reach and maintain an HR of 85%–90% of the maximum throughout the main phase. Subsequently, each HIIT was followed by a 2-min active recovery period, during which participants exercised at a lower intensity, targeting 50%–60% of the HR max, and ended with a 5-min cool-down. A smart HR

monitor (Aegon x1805) was utilized to monitor HR during the session.

Hypo-caloric diet (HCL)

Patients in this group were provided with tailored dietary plans that were aligned with their characteristics, including weight, age, financial circumstances, and lifestyle preferences. These dietary regimens were received day-after-day follow-up support. This involved regular communication through video calls or WhatsApp chats to monitor their dietary compliance and provide necessary guidance and encouragement.

Outcome measures

Body Compositions

Study employed the InBody 770 multifrequency bioelectrical impedance analysis scale (South Korea) to assess participants' body composition, such as fat mass and lean body mass (LBM). Herein, we manually recorded participants' age, gender, and height. Subsequently, participants were instructed to position themselves without shoes on the platform of the equipment, making sure that the bottoms of their feet touched the electrodes on the platform. Simultaneously, they gripped the device handgrips with their thumbs and fingers to sustain direct electrode contact, maintaining an upright posture with extended elbows for approximately 1 minute. The device employs impedance calculations for five body segments—trunk, arms, and legs—to provide detailed results in under 2 min. The BMI (kg/m2) was calculated using the weight and height values.

Waist Circumference (WC)

Employing a flexible, non-stretchable tape measurement to measure WC (cm), the patients were asked to stand comfortably with their feet together, arms at their sides, and wearing light clothing. Then, the tape was placed halfway between the patient's lowest rib and the top of the hipbone; the tape was comfy without squeezing the skin, measuring at the end of a normal exhalation.

adjusted weekly for eight weeks under the guidance of a specialized dietitian. To facilitate weight loss a calorie deficit strategy was implemented. Specifically, 500 calories were subtracted from their estimated daily calorie requirement.

To ensure adherence to the prescribed dietary regimen, patients in the diet group

EORTC QLQ-C30 Questionnaire

A global health/QoL scale and an economic impact item that includes 30 items grouped into five functional scales (Physical, Social, Emotional, Functioning, and Cognitive) and three symptom scales (fatigue, pain, and vomiting) [15].

Maximum Oxygen Consumption (VO2 max)

VO2 max was estimated based on HR data as follows: VO2 max = 15 x (HR max/HR rest [16]. HR max was determined through a modified Bruce protocol test, recording the participant's resting HR (HR rest) before starting the exercise test. During the progress through the stages of the exercise test on the treadmill, the participant's HR was continuously monitored via an HR monitor, considering the highest HR recorded throughout the exercise test to be the HR max.

Statistical analysis

Statistical analysis was conducted through SPSS version 25 for Windows (IBM SPSS, Chicago, IL, USA). An unpaired t-test was deployed to compare subject characteristics between groups. The data normal distribution and variance

homogeneity between groups were examined via the Shapiro-Wilk and Levene's tests, respectively. Our study used Mixed MANOVA to investigate the treatment effect on weight, BMI, WC, muscle and fat mass, HR rest, VO2 max, and EORTC QLQ-C30 while employing post-hoc tests using the Bonferroni correction for subsequent multiple comparisons. $P < 0.05$ indicated statistical significance

RESULTS

Patient characteristics

There was no significant difference between patient characteristics for both groups in the mean age, weight, height, or BMI ($p > 0.05$) (**Table 1, Fig. 2**).

Table 1 Comparison of patient characteristics between both groups

	Group A $\overline{X} \pm$ SD	**Group B** $\overline{X} \pm$ SD	**Mean difference (MD)**	**Unpaired t-value (T-value)**	**Probability value (P-value)**	**Sig**
Age (years)	47.8 ± 5.29	50.23 ± 6.99	–2.43	–1.٥١	0.1٣	Non-significant (NS)
weight (kg)	84.05 ± 7.48	85.07 ± 8.41	–1.02	–0.49	0.٦٢	NS
Height (cm)	160.93 ± 5.07	161.93 ± 4.71	–1	–0.79	0.٤٣	NS
BMI (kg/m²)	32.39 ± 2.03	32.36 ± 2.19	0.03	0.05	0.95	NS

$\overline{X}$: Mean **SD**: Standard deviation

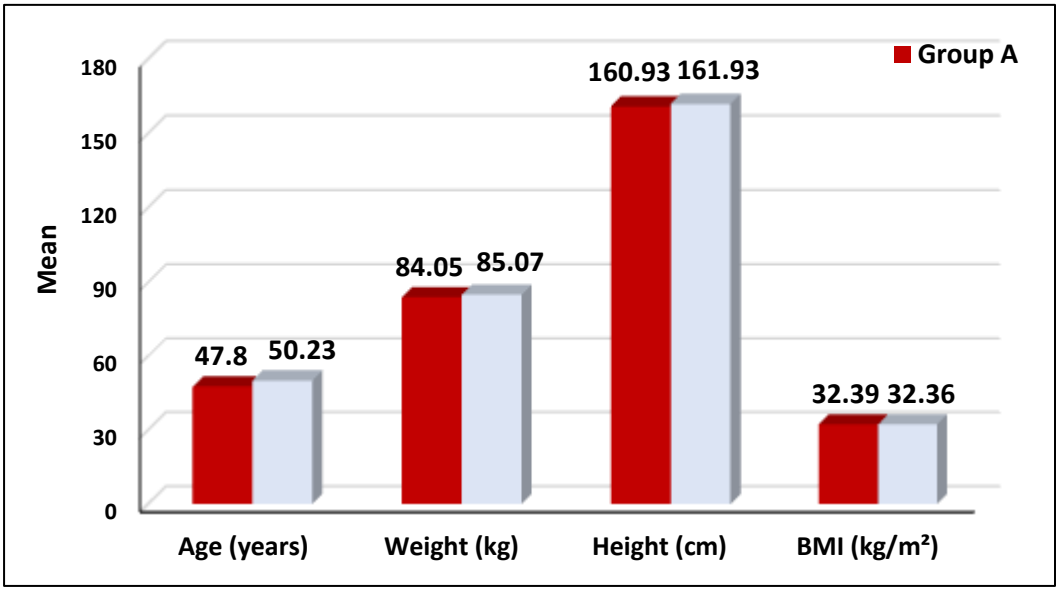

Fig. 2 Mean patient characteristics of both groups

Impact of treatment on weight, WC, BMI, muscle and fat mass, HR rest, VO_2 max, and EORTC QLQ-C30

The results of Mixed MANOVA showcased a significant interaction impact of treatment and time ($F = 30.03$, $p = 0.001$), with a significant main effect of treatment ($F= 2.34$, $p= 0.01$) and time ($F = 123.61$, $p = 0.001$).

Within group comparison

In comparison to pre-treatment, weight, BMI, WC, muscle mass, and fat mass exhibited a statistically significant improvement ($p < 0.001$) **(Table 2)** as well as HR rest was significantly reduced, and both VO_2 max and EORTC QLQ-C30 were elevated ($p < 0.001$) **(Table 3)** post-treatment in both groups.

Between-group comparison

Group B exhibited significantly lower BMI, HR rest, and fat mass ($p < 0.05$) and significantly higher EORTC QLQ-C30 ($p < 0.01$) than group A post-treatment. The VO_2 max

was significantly higher in group A than in group B post-treatment ($p < 0.01$). Moreover, weight, WC, and muscle mass did not significantly differ between both groups post-treatment ($p > 0.05$).

Table 2 Mean weight, BMI, WC, muscle mass, and fat mass pre- and post-treatment of both groups

	Pre-treatment	**Post-treatment**			
	Mean ±SD	**Mean ±SD**	**Mean difference (MD)**	**% of change**	**Probability value (p-value)**
		Weight (kg)			
Group A	84.05 ± 7.48	81.21 ± 7.68	2.84	3.38	0.001*
Group B	85.07 ± 8.41	78.46 ± 8.69	6.61	7.77	0.001*
MD	–1.02	2.75			
	p = 0.62	***p = 0.2***			
		Body mass index (kg/m²)			
Group A	32.42 ± 2.02	31.33 ± 2.25	1.09	3.36	0.001*
Group B	32.38 ± 2.19	29.85 ± 2.33	2.53	7.81	0.001*
MD	0.04	1.48			
	p = 0.95	***p = 0.01****			
		Waist circumference (cm)			
Group A	104.3 ± 7.28	102.23 ± 7.45	2.07	1.98	0.001*
Group B	١٠٤. ٥٣± ٨.٤٩	100.2 ± 8.61	4.33	4.14	0.001*
MD	–0.23	2.03			
	p = 0.91	***p = 0.33***			
		Muscle mass (kg)			
Group A	22.96 ± 2.32	23.36 ± 2.29	-0.4	1.74	0.001*
Group B	23 ± 2.58	24.14 ± 2.66	-1.14	4.96	0.001*
MD	–0.04	–0.77			
	p = 0.95	***p = 0.23***			
		Fat mass (kg)			
Group A	30.67 ± 4.71	29.39 ± 4.51	1.28	4.17	0.001*
Group B	30.69 ± 4.22	26.08 ± 4.97	4.61	15.02	0.001*
MD	–0.02	3.31			
	p = 0.98	***p = 0.009****			

SD: Standard deviation; *****: Significant difference

Table 3 Mean HR rest, VO_2 max, and EORTC QLQ-C30 pre- and post-treatment of both groups

	Pre-treatment	**Post-treatment**			
	Mean ±SD	**Mean ±SD**	**Mean difference (MD)**	**% of change**	**Probability value (P-value)**
			Resting heart rate (beats\min)		
Group A	82.7 ± 4.02	78.03 ± 4.98	4.67	5.65	0.001*
Group B	83.5 ± 4.56	81.77 ± 4.89	1.73	2.07	0.001*
MD	–0.8	–3.74			
	p = 0.47	***p = 0.005****			
			VO_2 max (mL/ kg /min)		
Group A	31.31 ± 2.18	33.23 ± 2.76	–1.92	6.13	0.001*
Group B	30.59 ± 2.63	31.26 ± 2.93	–0.67	2.19	0.001*
MD	0.72	1.97			
	p = 0.26	***p = 0.01****			
			EORTC QLQ-C30		
Group A	52.83 ± 8.97	58.73 ± 9.45	–5.9	11.17	0.001*
Group B	52.1 ± 9.63	64.93 ± 9.77	–12.83	24.63	0.001*
MD	0.73	–6.2			
	p = 0.76	***p = 0.01****			

SD: Standard deviation; ***:** Significant difference; **EORTC QLQ-C30**: European Organization for Research and Treatment of Cancer

DISCUSSION

Study aimed to examine and compare the clinical outcomes of HIIT and Hypo-caloric low-carb diet for eight weeks on body composition (fat- lean mass), cardiorespiratory parameters, and QoL in BC survivors. A significant improvement has been detected in both groups from pre- to post-treatment in all parameters. Also, a significant difference has been detected between groups in BMI, HR, fat mass, EORTC QOL-C30, and VO2 max. However, both groups had almost the same positive impact on weight, WC, and lean mass.

According to body composition, the HCL has better enhancement in weight, BMI, WC, muscle mass, and fat mass as the % of improvement was (7.77% - 7.81% - 4.14% - 4.96% - 15.02%) respectively, while the % change with HITT was (3.38% - 3.36% - 1.98% - 1.74% - 4.17%) respectively. Regarding cardiorespiratory parameters (HR-VO2 max), HIIT has a

more positive effect as the % of improvement was (5.65% and 6.13%) respectively, while the % change with HCL was (2.07% and 2.19%). After discussing the result, it was obvious that the QoL, according to the EORTC QOL-C30 score, improved with HCL as the % of improvement was 24.63%. Meanwhile, the improvement with HIIT was 11.17%.

Consistently, Wu Y et al. [17] they elucidated that a strong dedication to physical activity lowers BC risk. Engaging in moderate exercise resulted in a 2% reduction in risk, while strenuous activity led to a 5% reduction in risk. Samhan et al.[18] They illustrated that after three sessions of HIIT a week for eight weeks, they noticed a significant change in body composition, such as fat and muscle body mass. Natalucci et al. [19] study included 30 BC survivors who participated in a Mediterranean diet and aerobic exercise for a three-month home-based program and noticed an improvement in BMI. Jakicic et al.[20] have demonstrated that PA and exercise, on their own, do not result in weight loss. However, they have a crucial role in preventing weight gain and reducing the health risks connected with many chronic health disorders. Also, the findings of Reis et al.[21] support our study and demonstrated that home-based aerobic moderate to vigorous training conjugated with food orientation on food consumption for more than 150 min per week showed a positive role in losing weight in BC survivors.

Schmitz et al.[22] have implied that to achieve weight or fat loss, it is advisable to combine a nutritional intervention with exercise. Additional research has demonstrated that PA can diminish adipose tissue and enhance the development of lean muscle in individuals diagnosed with cancer. After three sessions of HIIT weekly for eight weeks, Tabaczynski et al. [23] demonstrated notable alternations in body composition (fat and muscle mass) and VO2 max can increase by 3.77 mL/kg/min. Studies by Friedenreich et al. [24] demonstrated that when evaluating the combined impact of diet and PA on losing weight in postmenopausal women, exercise alone did not significantly impact weight loss or reduction in BMI. Kang et al. [25] systematic review and meta-analysis showcased that metabolic indicators were significantly more impacted in participants undergoing intervention achieved weight reduction. Thus, the PA impact on some metabolic indicators may be associated with alterations in body weight.

Foulkes et al.[26] cleared that BC survivors with more than two cardiovascular disease (CVD) risk factors had a reduced CRF level, rendering them at high risk for both BC and cardiovascular death. Results from submaximal VO2 exercise testing indicated that the gold standard for assessing therapies aimed at enhancing CRF is the VO2 max test in BC survivors. Contrary to us, Rock et al.[27] indicated no significant alternations in fat mass, LBM, or BMI following HIIT interventions. Nevertheless, the control group had a non-significant rise in body weight and fat mass. Thus, patients are advised to refrain from gaining weight post-therapy to enhance BC outcomes.

The systematic review and meta-analysis of Sultana et al. [28] manifested that HIIT is ineffective in reducing total body fat mass or fat percentage compared to a non-exercise control group and Moderate Intensity Continuous Training (MICT). The main result of Isanejad et al.'s [29] study was that HIIT resulted in an enhancement of CRF in comparison to both the control and MICT groups. Similarly, Toohey et al.[30] manifested that low-volume HIIT constitutes a promising and efficient

intervention for individuals with cancer that leads to significant gains in CRF. In addition, Yeh et al.[31] showed that HIIT or MICT interventions led to enhanced CRF in obese BC survivors. Furthermore, they observed that HIIT did not yield any extra advantage when compared to MICT in enhancing aerobic power. Research has demonstrated that individuals with a low VO2 peak level (<18 mL/kg/min) had a greater risk of developing heart failure in BC patients.

In the same line with our study, Scott et al.[32] demonstrated a significantly increased CRF (2.80 mL O2/kg/min) and –1.92 mL O2 /kg/min mean difference between pre-and post-treatment, which supports the recommendation that exercise therapy improves impaired VO2 peak in patients with cancer. On the other hand, Okumatsu1 et al.[3] concluded that by applying a combined exercise with a diet program, survivors showed increased CRF as VO2 peak raised from 26.7 to 30.4 mL/kg/min and decreased body weight and the reduction in BMI was 2.1 kg/m2.

Travier et al.[33] found that regardless of the specific questionnaire utilized, fatigue was significantly reduced, and both physical and mental health were improved, which contributed to an overall QoL improvement. This was independently linked to the observed change in Peak Power Output relative to body mass throughout the intervention. The findings of Fong et al.'s[34] meta-analysis has supported the association between PA and experiencing improvements in fatigue, depression, and QoL among BC survivors.

Conclusion

Study found that High-Intensity Interval Training (HIIT) can improve cardiorespiratory fitness (CRF) more than a Hypocaloric Diet (HCL). The HCL has a greater impact on BMI, adipose tissue, and quality of life score than HIIT. Therefore, combining both therapies may enhance their positive clinical impact and help reduce the risk and complications for breast cancer patients.

RECOMMENDATION

Based on the findings of this study, no Recommendations

Further studies may include a larger number in each group and a longer duration of more than three months. This study suggested applying another study with a study group undergoing the effects of both treatments, HIIT and HCL diet. More investigations will be needed to evaluate the impact of HIIT and HCL diet on insulin resistance for BC survivors. Assess the long-term effect of both treatments on patients after six months and one year.

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Authors’ contributions

This work was carried out in collaboration with all authors. ZS, BH, and HE designed the study, wrote the protocol, and wrote the first draft of the manuscript. AM, BH, and HE managed the data collection for the study. All authors read and approved the final manuscript.

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Availability of data and materials

All data generated or analyzed during this study are included in this article.

Declarations

Ethics approval and consent to participate

The Cairo University's Academic and Ethical Council authorized this study with the approval number of (P.T.REC/012/004286). All participants in this trial signed informed consent. Our study followed the International Medical Association's rule of ethics for human studies, the Helsinki Declaration.

Competing interests

No competing interests.

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