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ORIGINAL RESEARCH

Using Inspiratory Muscle Training to Improve Respiratory Strength, Functional Capacity, Fatigue, and Stress in Breast Cancer Patients Undergoing Surgery

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Purpose: The main aim of the trial was to assess the effectiveness of inspiratory muscle training on respiratory muscle strength, functional capacity, fatigue, and stress in post-surgical breast cancer survivors.

Methods: Forty-seven females who had undergone unilateral post-mastectomy were randomly assigned to an intervention group (IG; n = 24) and a control group (CG; n = 23). Both groups received aerobic exercise training. In addition, the intervention group received inspiratory muscle training 3 days a week for 8 weeks. Maximum inspiratory and expiratory pressure (Pimax) (Pemex), 6-minute walk test, Handgrip strength by hand-held dynamometer, Fatigue Assessment Scale (FAS), and Perceived Stress Scale pss 10 values were measured before the training and then at the eighth week for both groups.

Results: No differences were detected between the groups in terms of sample and clinical characteristics 8 weeks post-intervention. In favor of the intervention group, a significant difference with medium to high effect size was found in terms of Pimax, Pemax, FAS, PS, and 6MWT ($p < 0.05$). However, there was no difference in terms of handgrip strength (p-value: 0.072), with a medium effect size (0.070). Regarding within-group comparisons, IG exhibited substantial differences in all outcome measures ($p < 0.05$) compared to CG, with the exception of PImax and 6MWT.

Conclusion: In post-operative breast cancer survivors, respiratory muscle training combined with aerobic training increases respiratory muscle strength and functional ability while lowering stress and tiredness.

Keywords: aerobic exercises, breathing muscles, function, mastectomy

Introduction

Breast cancer (BC) is a condition in which abnormal breast cells develop violently and generate tumors. If neglected, these lesions may expand across the body and become life-threatening. Globally, it is the most often reported cancer type, estimated at 2.3 million new cases (11.7%), and 685,000 deaths in 2020 alone, and it is expected to reach 4.4 million in 2070.[1,2] In Saudi Arabia, breast cancer has increased by 55%, accounting for 30.9% of all cancer cases among Saudi women. The median age has risen to 51 years, with an overall increase of 6.3%.[3]

Treatments of BC may include chemotherapy, radiation therapy, hormone therapy, surgery, or a combination of these. Some of the most upsetting side effects of these treatments include fatigue, difficulties sleeping, discomfort, stress, physical problems, and decreased cardiac and pulmonary function.[4] The prognosis for BC patients has significantly

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improved. However, long-lasting negative physical and psychological effects are still experienced by BC survivors, including psychosocial distress and physical dysfunction.[5]

Aerobic training is a beneficial treatment strategy for reducing long-term negative consequences for BC patients. It has several positive effects, including enhanced physical ability, muscular power, and improved psychological well-being.[6] Aerobic training can increase oxygen delivery and lung diffusion capacity by increasing blood volume, hemoglobin concentration, and cardiac output. In addition, aerobic training can improve the oxidative capacity of skeletal muscle by enhancing the size and number of mitochondrial and aerobic enzyme activity.[7]

There are many types of treatments for BC that can be harmful to the respiratory system.[8] It has been found that breast surgery has negative consequences such as postoperative pain, circulatory and respiratory problems, muscle weakness, and changes in cough reflexes.[9]

Additionally, a radical mastectomy has a negative impact on body posture, which can alter ventilatory mechanics and impair respiratory functions. This results in decreased respiratory muscle strength, and decreased thoracic mobility.[10,11]

Abbas et al conducted a retrospective cohort study to determine the long-term respiratory complications of breast cancer oncological treatments, revealing the close relation between BC treatment modalities and respiratory complications, including pneumonitis and fibrosis.[12]

Respiratory physiotherapy is a set of techniques intended to prevent, treat, and stabilize cardiorespiratory disorders.[13] It is a helpful approach to preserving and enhancing functional capacity, quality of life, and post-treatment sequelae following breast cancer care.[14,15] However, there is little evidence of the benefits of adding inspiratory training into aerobic regimens for breast cancer survivors who have undergone surgery. Thus, the purpose of this study was to assess inspiratory muscle training's efficacy in post-surgical breast cancer survivors. In comparison to an exercise training program offered without inspiratory training, we hypothesized that adding inspiratory muscle training to an aerobic exercise training program would result in larger improvements in hand grip, fatigue, stress, and respiratory muscle strength.

Materials and Methods

This study was randomized and controlled, took place between October 2023 and January 2024, following the Helsinki Declaration principles, and was reported according to the CONSORT statement.[16] The protocol was approved by the University of Ha'il ethical committee board under no. H-2023-367. Additionally, the study protocol was registered on clinicaltrials.gov (no: NCT06091696). A consent form was signed by all participants before joining the study, and the participants were informed about the purpose of the study before starting the intervention.

The inclusion criteria were as follows: 1) females; 2) age range: 40–70 years old; 3) subjected to surgical treatment of breast cancer during the last 2 to 4 weeks 4) any kind of surgical approaches were included; 5) score ≤ 2 on ECOG (Eastern Cooperative Oncology Group); 6) completion of adjuvant chemotherapy and /or radiotherapy treatment course.

The exclusion criteria were as follows: 1) having liver and/or brain metastasis for patients with metastatic breast cancer; 2) having any communication and psychiatric problems; 3) not willing to sign the consent form; 4) skipping 2 consecutive sessions; 5) contraindications to exercises as requested by the physician.

Sample Size

The estimation of the sample size was based on the maximum inspiratory pressure (Pimax) mean and standard deviations retrieved from previous studies.[17,18] Using G-power software (3.1.9.7; Heinrich-Heine-Universität Dusseldorf, Dusseldorf, Germany), 48 participants (24 per group) were deemed appropriate to achieve an effect size of 0.241 when the power was 80%, the α was 0.05, and the allocation ratio was 1:1. A total of 53 were recruited to compensate for any dropouts.

Interventions

Standard care was provided to both IG and CG, including advice, active lifestyle, and arm care. IG underwent both inspiratory muscle training and aerobic exercise training, while CG underwent aerobic exercise only.

Inspiratory Muscle Training

Following Gosselink et al's study in 2011 and Han-Yu Chuang et al's study in 2017,[19,20] inspiratory muscle training was performed using Threshold Inspiratory Muscle Training Respironics (Pittsburgh, PA, USA). The pressure threshold training loading in the first week was set at 15 cmH_2O, which was then gradually increased to 20 cmH_2O in the second and third weeks, then to 30 cmH_2O in the fourth to the sixth week, and then increased to 40 cmH_2O in the eighth week according to the patient's tolerance. The training was done in a relaxed sitting position using a nose clip for 10 minutes per session, 6 sets of 10 repetitions. The patients were directed to breathe through a mouthpiece at the desired training workload. Each set consisted of five deep inhalations against the training device, with a brief rest period of 1–2 minutes in between. The training was performed once per day, thrice a week for 8 weeks.[21,22]

Aerobic Exercise Training

Exercise training sessions under the supervision of an experienced physiotherapist were conducted for 30 min, 3 times per week, with intensity ranging between 13 and 15 of rated perceived exertion RPE.

The first 3 to 7 days post-operative the patient is instructed to gradually exercise her affected upper limb per the following instructions: raise her arms to shoulder height as much as she can tolerate, 3 or 4 times a day; hand squeeze 15 to 25 times; elbow flexion and extension; hand touch to the shoulder on the same side and opposite side a few times; and practice diaphragmatic breathing exercise at least 6 times a day.[23]

In the second and third weeks, the patients did the following exercises with 5 to 7 repetitions: (1) wand exercise, (2) elbow winging exercises, (3) shoulder stretch exercises, (4) shoulder squeeze exercises, (5) side bends exercises in sitting position, (6) chest wall stretch in standing position.[23–25]

From the fourth to the eighth week, the patients were started on the following aerobic exercise. The training session started with a warm-up and cool-down for 10 minutes, including light aerobic and stretching activity, followed by 20 minutes of pumping exercise for the upper limb, pendulum exercises, and shoulder shrugs and rotation (2 sets 15 repetitions).[26]

Outcomes Measurement

All outcomes were assessed twice, that is, before and after the treatment. A therapist with 15 years of experience was responsible for the initial screening of the subjects and data collection.

1. Inspiratory strength by maximal inspiratory and expiratory pressure (PImax) (Pemex)

The PImax and Pemex were assessed using a respiratory mouth pressure meter device (Micro RPM, Micro Medical Ltd, Kent, UK).[27] The assessments were performed while each patient was sitting, using a nasal clip. The patients were instructed to forcefully breathe with their lips on the mouthpiece to avoid air leakage. The PImax and Pemex were measured by deep inspiration and expiration through the mouthpiece starting from the residual volume.[28]

2. Functional exercise capacity was evaluated by a 6-minute walk test (6MWT).

The 6MWT was validated[29] and used to assess the impact of treatment and prognosis. The participants were asked to cover as much distance as possible walking in 6 min without running. The maximum distance covered at the end of the test was recorded.[30,31]

3. Handgrip strength

Hand-grip strength of the dominant hand of the affected upper limb was assessed using the procedures performed in a recent study[32] where a Lafayette push hand-held dynamometer (model 01163, Lafayette Instrument Co., Lafayette, IN, USA) was used to measure hand grip strength in Kg. It is a validated and reliable tool for assessing hand isometric strength.[33] The patients were made to sit in the abducted tested arm position and the elbow was at 90° of flexion. They

were asked to squeeze the handle of the device as hard as possible and then relax. This procedure was repeated thrice with 1-minute rest intervals. The average of the recorded readings was used for the analysis.[34]

4. Fatigue Assessment Scale (FAS)

The Fatigue Assessment Scale (FAS) is a 10-item validated and reliable scale used for evaluating symptoms of chronic fatigue.[35] It is a self-report measure requiring 2 min for administration.[36] FAS scoring was done using a five-point Likert-type scale ranging from 1 ("never") to 5 ("always"). Total scores can range from 10, indicating the lowest level of fatigue, to 50, denoting the highest.[37]

5. Perceived stress (Perceived Stress Scale pss 10)

It is used as a psychological tool for stress perception measurement. It is an indicator of how stressful one considers certain circumstances in their life to be.[38] PSS scores can range from 0 to 40, with higher scores indicating higher perceived stress, scores ranging from 0 to 13 would be considered low stress, and scores ranging from 14 to 26 would be considered moderate stress.[39]

Randomization, Concealment, and Blinding

This study was a double-blinded (assessor and data analyzer) one. Coin toss randomization was used to randomly assign women to the intervention group (IG) and control group (CG) after the baseline evaluation. The IG participants followed both the inspiratory and aerobic exercise training protocols, while the CG received only the aerobic exercise training protocol. During data collection, four patients (three in the IG and one in CG) discontinued the intervention for social reasons. Patients underwent two evaluation sessions: before intervention (initial assessment) and immediately after the 8-week intervention period (final assessment).

Statistical Analysis

IBM, Armonk, New York's SPSS for Windows (V.27) was used to evaluate all the data. A comparison of baseline and demographic data was made between both groups. The Kolmogorov–Smirnov test was used to determine if the acquired data were normal. The two-way repeated ANOVA was used to evaluate changes within and between groups. The 95% confidence interval (CI) is presented with the adjusted mean differences within and between groups. Furthermore, the effect size between the intervention and control group was calculated using partial eta squared value; a p~<0.05 was used.

Results

Fifty-one postoperative breast cancer female patients who fulfilled the criteria were randomly allocated to the IG and CG. Three patients in the intervention group and one patient in the control group left the trial for non-medical reasons (Figure 1). The mean age for IG was 47.12±4.38 and body mass index (BMI) was 25.66±2.038. For CG, the mean age was 48.30±3.86 and BMI was 24.67±1.78. Both groups had undergone chemotherapy or radiotherapy treatment before surgery. Chemotherapy was given to 40.4% of the patients, while radiotherapy was given to 59.6% of the patients. The patients were exposed to different types of surgeries: radical mastectomy (23.4%), modified radical mastectomy (59.6%), and lumpectomy (17.00%) (Table 1).

Between-group comparisons demonstrated a statistically significant difference in Pimax, Pemax, FAS, PS, and 6MWT, with medium to high effect size in favor of the intervention group. On the other hand, no statistically significant difference was determined between the groups regarding handgrip strength (*p*-value: 0.072), with the effect size being medium (0.070), as presented in Table 2.

The within-group comparisons demonstrated statistically significant differences in the intervention group regarding all outcome measures (p values <0.05). However, in the control group, the results showed significant differences in all measures except PImax and 6MWT (*p*-value: 0.070 and 0.293, respectively), with the measured values being higher in

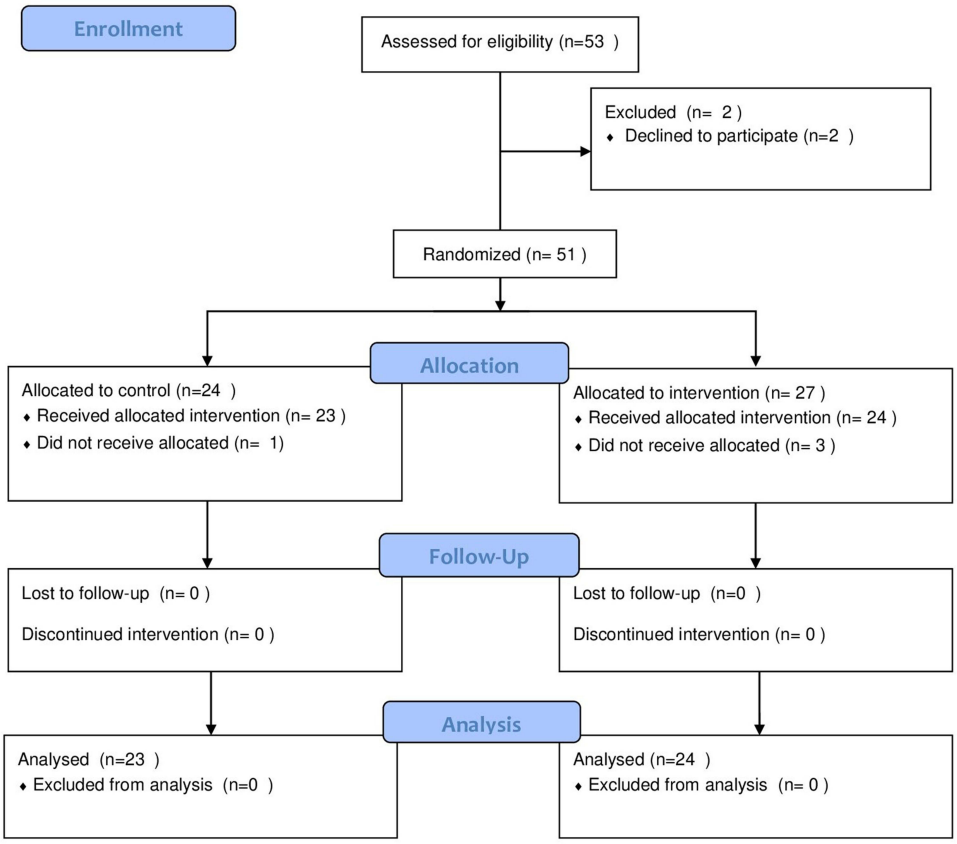

Figure 1 flow diagram.

the IG than the CG post-intervention (PImax: 88.79±5.45 vs 68.69±2.83; Pemax: 138.5±3.47 vs 133.2±3.68; 6MWT: 399.66±24.38 vs 381.86±30.58; handgrip: 27.08±2.43 vs 25.73±2.57; FAS: 13.00 ±2.04 vs 18.56±1.82; PS: 10.29±1.62 vs 13.13±1.32), as displayed in Table 3.

Table 1 Sample Characteristics

	Intervention Group (n=24)	Control Group (n=23)	Total (n=47)
Age, years	47.12±4.38	48.30±3.86	47.7±4.13
BMI, Kg/m^2	25.66±2.038	24.67±1.78	25.17±1.9
Types of treatment before operation n (%)			
Chemotherapy	8 (33.3%)	11 (47.8%)	19 (40.4%)
Radiotherapy	16 (66.6%)	12 (52.2%)	28 (59.6%)
Types of operation n (%)			
Radical mastectomy	6 (25%)	5 (21.7%)	11 (23.4%)
Modified radical mastectomy	13 (54.24%)	15 (65.21%)	28 (59.6%)
Lumpectomy	5 (20.24%)	3 (13.04%)	8 (17.02%)

(*Continued*)

Table 1 (Continued).

	Intervention Group (n=24)	Control Group (n=23)	Total (n=47)
Affected arm (%)			
Dominant	21 (87.5%)	22 (95.6%)	43 (91.5%)
Non dominant	3 (12.5%)	1 (4.4%)	4 (8.5%)
Education level, n(%)			
High school or less	3 (12.5%)	4 (17.4%)	7 (14.9%)
College	14 (58.3%)	10 (43.5%)	24 (51.06%)
Post graduate	7 (29.16%)	9 (39.1%)	16 (34.04%)

Abbreviation: BMI, body mass index.

Table 2 Between-Group Comparisons at Baseline and Post-Treatment

Variable	Time	Intervention G	Control G	MD	95% CI		F	P	ηp2
		M ± SD	M± SD						
Pimax	Baseline	68.29±2.59	67.13±2.88	1.16	−0.44	2.77	2.11	0.135	0.045
	Post	88.79±5.45	68.69±2.83	20.09	17.52	22.66	247.94	0.000	0.997
PeMax	Baseline	130.12±4.83	128.26±5.31	1.86	−4.77	1.05	1.587	0.214	0.034
	Post	138.50±3.47	133.26±3.68	5.24	3.19	7.29	25.166	0.000	0.359
6MWT	Baseline	374.45±27.57	372.60±28.39	1.84	−14.59	19.29	0.051	0.822	0.001
	Post	399.66±24.38	381.86±30.58	17.79	1.58	34.01	4.88	0.032	0.098
Handgrip	Baseline	21.79±3.20	20.34±2.34	1.44	−0.211	3.09	3.08	0.086	0.064
	Post	27.08±2.43	25.73±2.57	1.34	−0.127	2.81	3.38	0.072	0.070
FAS	Baseline	24.66±2.54	23.95±2.20	0.710	−0.692	2.11	1.04	0.313	0.023
	Post	13.00±2.04	18.56±1.82	5.56	−6.70	−4.42	96.48	0.000	0.682
PS	Baseline	15.66±1.63	16.34±1.46	0.68	−1.59	0.231	2.25	0.140	0.048
	Post	10.29±1.62	13.13±1.32	2.83	−3.71	−1.69	42.77	0.000	0.487

Abbreviations: PImax, maximum inspiratory pressure; PeMax, maximum expiratory pressure; min, minute; 6MWT, 6 min walk test;FAS, Fatigue Assessment Scale; PS, Perceived stress;; M, mean; SD, standard deviation; MD, mean difference; t, t value; CI, confidence interval; p, significance; ηp2, partial eta squared.

Table 3 Within Group's Comparisons at Baseline and Post-Treatment

Variable	Time	Baseline	Post	MD	95% CI		F	P	ηp2
		M ± SD	M± SD						
PImax	Intervention	68.29±2.59	88.79±5.45	20.5	−22.43	−18.56	276.521	0.000	0.857
	Control	67.13±2.88	68.69±2.83	1.56	−2.27	−0.853	3.448	0.070	0.073
PeMax	Intervention	130.12±4.83	138.50±3.47	8.37	−10.75	−6.01	47.528	0.000	0.508
	Control	128.26±5.31	133.26±3.68	5.00	−7.64	−2.36	13.767	0.001	0.238

(*Continued*)

Table 3 (Continued).

Variable	Time	Baseline	Post	MD	95% CI		F	P	ηp2
		M ± SD	M± SD						
6MWT	Intervention	374.45±27.57	399.66±24.38	−25.20	−36.20	−14.20	11.256	0.002	0.197
	Control	372.60±28.39	381.86±30.58	−9.26	−15.00	−3.52	1.133	0.293	0.025
Handgrip	Intervention	21.79±3.20	27.08±2.43	−5.29	−6.24	−4.33	41.574	0.000	0.475
	Control	20.34±2.34	25.73±2.57	−5.39	−6.32	−4.46	54.950	0.000	0.555
FAS	Intervention	24.66±2.54	13.00±2.04	11.66	10.46	12.86	306.250	0.000	0.869
	Control	23.95±2.20	18.56±1.82	5.39	4.49	6.29	81.433	0.000	0.649
PS	Intervention	15.66±1.63	10.29±1.62	5.37	4.55	6.19	130.406	0.000	0.739
	Control	16.34±1.46	13.13±1.32	3.21	2.49	3.94	61.029	0.000	0.581

Abbreviations: PImax, maximum inspiratory pressure; PeMax, maximum expiratory pressure; min, minute; 6MWT, 6 min walk test;FAS, Fatigue Assessment Scale; PS, Perceived stress;; M, mean; SD, standard deviation; MD, mean difference; *t*, t value; CI, confidence interval; p, significance; *ηp2*, partial eta squared.

Discussion

This trial aimed to explore the effect of adding respiratory exercises to usual aerobic exercise in post-operative breast cancer women. The hypothesis was that adding inspiratory training to an aerobic program would improve strength, fatigue, stress, and physical capacity for post-surgical breast cancer women. When comparing both study groups, we found that combined inspiratory and aerobic training has been proven to improve inspiratory muscle strength, physical capacity, fatigue, and stress for breast cancer patients. However, regarding grip strength, no statistical changes were found (*p*-value: 0.072). No significant negative consequences associated with our study training program have been documented. These findings have significant positive implications for breast cancer survival and clinical care.

It is estimated that 30–80% of cancer patients have several age-related chronic diseases, such as metabolic, cardiovascular, and pulmonary disorders. Consequently, the oxygen cycle and ventilation are negatively affected. Women with breast cancer besides these adverse effects of aging have reduced respiratory fitness, which is caused by unfavorable changes in systolic and diastolic function, lung elastic recoil, ventilation, vascular conductance, and oxidative capacity.[7,40,41]

Chest wall muscle was affected during mastectomy, which led to decreased thoracic expansion, respiratory muscle strength weakness, and altered respiratory mechanics.[8] Moreover, patients who have had breast cancer surgery have decreased respiratory muscle strength. The researcher proved that these changes are due to the use of analgesics, shallow breathing, the presence of a surgical drain, and fear of pain.[42]

Previous research has explored the benefits of organized exercise training on a variety of psychological and physiological outcomes for breast cancer patients. There are numerous health benefits associated with exercise training, including improvements in life quality,[43] fatigue, and physical capacity.[44–46] In the current study, post-operative breast cancer patients were found to benefit from combined inspiratory and aerobic training. Our findings are in agreement with the study done by Dahhak et al, who investigated the effect of inspiratory muscle training (IMT) on breast cancer women, which showed improvements in inspiratory muscle power, and no difference between the groups was detected in terms of 6MWT; in addition, grip strength showed no change.[17] There are a few differences between their study and ours. For instance, we used IMT (gradually increased intensity according to patient tolerance) combined with aerobic training for the study group versus aerobic training only for the control group, while Dahhak used IMT for both study groups with different intensities plus strength training.

The main findings of the study by Ray et al were that training of respiratory muscle (RMT) enhances inspiratory muscle power and physical capacity, as well as reduces fatigue among breast and lung cancer patients.[47] These findings corroborate our theory that, among post-operative breast cancer patients, adding respiratory muscle training seems to enhance inspiratory muscle power and physical capacity and decrease fatigue. Notably, Ray et al's study involved both

breast and lung cancer patients and was performed on a small sample size (10 subjects), with a short duration of follow-up of only 4 weeks.

Similarly, Duruturk et al showed that inspiratory muscle training improved respiratory muscle strength and exercise capacity and reduced fatigue among asthmatic patients.[48] This study was different from our trial in that all individuals had mild to moderate asthma, the exercise program lasted only six weeks, and a placebo group was used.

The present study's findings are in line with those published by Al-Najar et al, according to whom, after mastectomy, respiratory muscle training has a demonstrable and considerable influence on ventilatory functions and dyspnea. This is especially true when paired with physical therapy rehabilitation.[49] This study was slightly different from the current study: first, respiratory training was done using a breather device; second, the frequency was twice per week; third, they measured ventilator function (Spirometer) and dyspnea without any measures related to respiratory muscle power.

Patients with breast cancer experience psychological issues such as anxiety or depression and worry about the illness returning, as well as reduced quality of life.[50] Our results revealed that combined respiratory and aerobic training had a positive effect on stress and fatigue in post-operative breast cancer women. These results are in agreement with those published by Mijwel et al, who investigated the impact of high-intensity exercise therapy on fatigue and quality of life in women with breast cancer after chemotherapy; their results demonstrated positive benefits on cancer-related physical, behavioral, emotional, and cognitive fatigue.[51]

In 1987, the National Institute for Mental Health (NIMH) released a consensus statement about the impact of exercise on mental health. The report stated that physical activity has a favorable impact on mental health and well-being, reduces stress hormones and other stress indices when done appropriately, and has positive emotional impacts on people of all ages and genders.[52]

The management of breast cancer survivors has a direct impact on their cardiopulmonary symptoms because of tumor location, chest wall irradiation, vascular dysfunction, and chemotherapy-induced peripheral muscle weakness.[53] Respiratory muscle dysfunction has a role in the burden of symptoms and decreased exercise capacity experienced by breast cancer survivors.[54]

Due to the high incidence of cardiovascular, pulmonary, and psychological consequences in post-operative breast cancer surgery, these are essential targets for physiotherapy intervention.[55] Previous investigation has suggested that all post-operative breast cancer surgery women are in desperate need of rehabilitation physically and psychologically. Effective physical rehabilitation incorporates a significant enhancement in physical and psychological well-being.[56–58]

There are a few possible limitations to this research, such as a small sample size, the inclusion of only three forms of breast surgery (lumpectomy, modified radical mastectomy, and radical mastectomy), and a lack of follow-up. Future studies must investigate the role of respiratory muscle training in different groups of post-operative breast cancer survivors with different outcome measurements.

Conclusion

In conclusion, in post-operative breast cancer survivors, respiratory muscle training seems to have a favorable impact on respiratory muscle strength, exercise performance, fatigue, and stress. The current study highlights the significance of respiratory muscle training in conjunction with aerobic exercise for enhancing physical capacity and respiratory muscle strength in post-operative breast cancer survivors, as well as for lowering stress and tiredness. Enhancing future studies and applying comparable investigations with large samples may boost the generalizability of the results.

Data Sharing Statement

In case of reasonable request, the corresponding author will provide all datasets generated and/or analyzed during the current study.

Ethical Approval and Consent of Participants

This study was conducted according to the guidelines of the Declaration of Helsinki and was approved by the University of Ha'il ethical committee board under no. H-2023-367, Informed consent was obtained from all subjects before

participating in the study by signing the consent form before data collection, all participants were informed about the purpose of the study before starting the intervention.

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Disclosure

The authors declare no conflicts of interest in this work.

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