

Circuit Weight Training Enhances Quality of Life and Functional Outcomes in Breast Cancer Survivors: A Randomized Controlled Trial

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Purpose: This study was intended to explore the effectiveness of Circuit Weight Training (CWT) on quality of Life, balance, strength, and functional Capacity in female breast cancer patients.

Patients and Methods: Fifty female post-mastectomy patients, aged 35 to 50 years, were recruited. They were randomly split into two equal groups: a control group and a study group. Both groups participated in a standardized physiotherapy program thrice weekly for eight weeks, focusing on shoulder mobility exercises under expert supervision. In addition, Group A (study group, n = 25) performed a Circuit Weight Training (CWT) protocol alongside physiotherapy, consisting of two exercise circuits per session with functional and aerobic components, conducted at moderate intensity. Group B (control group, n = 25) received the physiotherapy program without the CWT component. Outcome measures included muscle strength (measured via a Handheld Dynamometer), postural stability and limits of stability (assessed using the BIODEX Balance System SD), functional capacity (evaluated with the 2-Minute Step Test), and health-related quality of life (HRQoL) (assessed via the 12-item Short Form Survey).

Results: The study group indicated statistically significant improvements in muscle strength: 14.98% (middle and lower trapezius), 17.37% (teres major), 19.79% (latissimus dorsi), 13.63% (quadriceps), 15.59% (hamstrings), 19.63% (gluteus maximus), 14.60% (gluteus medius), 14.95% (dorsiflexors), and 12.87% (plantar flexors) (P = 0.001). Improvements were also observed in balance parameters: limits of stability (38.18%), postural stability (47.69%), and single-leg stance (49.67%) (P = 0.001). Functional capacity increased by 36.50% (P = 0.001). Additionally, significant improvements in HRQoL were recorded: 49.82% in the mental section and 50.33% in the physical section of SF-12 (P = 0.001).

Conclusion: Circuit Weight Training significantly enhances postural stability, muscle strength, functional capacity, and HRQoL in postmastectomy breast cancer patients. These findings underscore the value of incorporating structured exercise programs into oncology rehabilitation protocols.

Keywords: breast cancer, circuit weight training, post-mastectomy, quality of life

Introduction

With an estimated 2.3 million new cases reported annually, breast cancer (BC) is the leading cause of cancer-related deaths among women and a significant threat to global health.¹ Twenty-two percent of all female deaths caused by cancer in Egypt originate from BC.² Survival rates have significantly increased as a result of advances in screening and treatments. Nowadays, 70–80% of individuals with non-metastatic, early-stage disease are curable.³ Within the next ten years, it is anticipated that there will be well over two million more breast cancer sufferers in the US alone.⁴

Breast cancer management necessitates a multidisciplinary approach, integrating medical, surgical, and radiation oncology.⁵ Due to early diagnosis and improved therapeutic strategies, survival rates have increased, with approximately 88% of BC patients surviving beyond five years.⁶ However, long-term survivorship comes with challenges, as many patients continue to experience medical, psychological, and social difficulties even a decade post-diagnosis.⁶

Impaired balance is one of these problems that has a considerable effect on BC survivors' quality of life (QoL). Balance control is essential for both static (stationary) and dynamic (moving) stability, and impairments in these domains can significantly impact functional independence.⁷ Functional capacity, a person's capability to do routine duties, work, and mobility-related tasks, is another key determinant of overall well-being.⁸

Middle-aged women need to be encouraged to stay physically active and do activities that enhance their motor and sensory abilities to improve posture control and lower their risk of falling.⁹ Exercise-based interventions are particularly relevant for promoting healthy aging.¹⁰

Despite longer survival, breast cancer treatments leave long-term sequelae, including functional decline, fatigue, depression, neuropathy, lymphedema, reduced immunity, and loss of flexibility, all of which adversely affect the QoL.¹¹ Given their profound effects on functioning independence, QOL, and long-term survivorship, addressing these issues should be a fundamental component of cancer rehabilitation.

Despite increasing attention to the rehabilitation of patients with BC, there is little quantitative data about the effectiveness of Circuit Weight Training (CWT) on functional capacity and QoL in this population. While earlier research has explored the benefits of general exercises, the role of CWT as a targeted intervention for improving balance, strength, and overall functional independence remains underexplored.

Materials and Methods

Design of the Study

The study was a Randomized Controlled Trial. This trial was approved by the Ethical Committee of the Faculty of Physical Therapy, Cairo University. The study was anticipated registered in the Clinical Trial Registry (NCT06936241). The Ethical Committee of Cairo University's Faculty of Physical Therapy, Giza, Egypt (P.T.REC/012/005445) endorsed the proposal for this work—Bahyea IRB Protocol number (20241021004). By applying opaque, sealed, and sequentially numbered envelopes, the participants were randomly split into two equal groups. The therapist prepared fifty-two sealed envelopes, each containing a card labeled “control” or “study”. Lastly, each one was requested to appeal a sealed envelope that indicated her group allocation to the study or control groups. All participants provided informed consent, in accordance with the Declaration of Helsinki.

Subjects

Forty-six female post-mastectomy patients, according to the G*power computer program (version 3.1.9.2; Franz Faul, Universität Kiel, Germany) based on data of balance derived from (Park and Kim, 2016)¹² and revealed that the required sample size for this study was 23 subjects in each group. Calculation is made with $\alpha=0.05$, power = 80%, and effect size = 0.85. The sample increased to 52 (26 per group) for a possible 10% dropout. Unfortunately, two participants dropped out due to worsening health conditions and the detection of previously unknown brain metastases. Ages from 35 to 50 years old were recruited in this study. These participants were allocated from the Physical Therapy department at Baheya Centre for Early Detection and Treatment of Breast Cancer, Giza, Egypt. Females with the diagnosis of non-metastatic (Stage 0-III) breast cancer who were referred to physical therapy 4 weeks post-mastectomy and treated with neoadjuvant chemotherapy before surgery were included. They aged between 35 and 50, and their BMI was < 30. They were prohibited from participating if they had lymphedema, rheumatic disorders, neurological, skeletal, or cancer metastases, along with any neurological, cognitive, vestibular, or visual impairment that would currently prevent them from engaging in a safe manner. Every female patient underwent the same medical and conventional physical therapy care, and they were all assessed by the same doctor and physiotherapist. Patients were randomly assigned (1:1) to either Group A (Study group) or Group B (Control group). Study group comprised 25 patients who performed CWT plus their

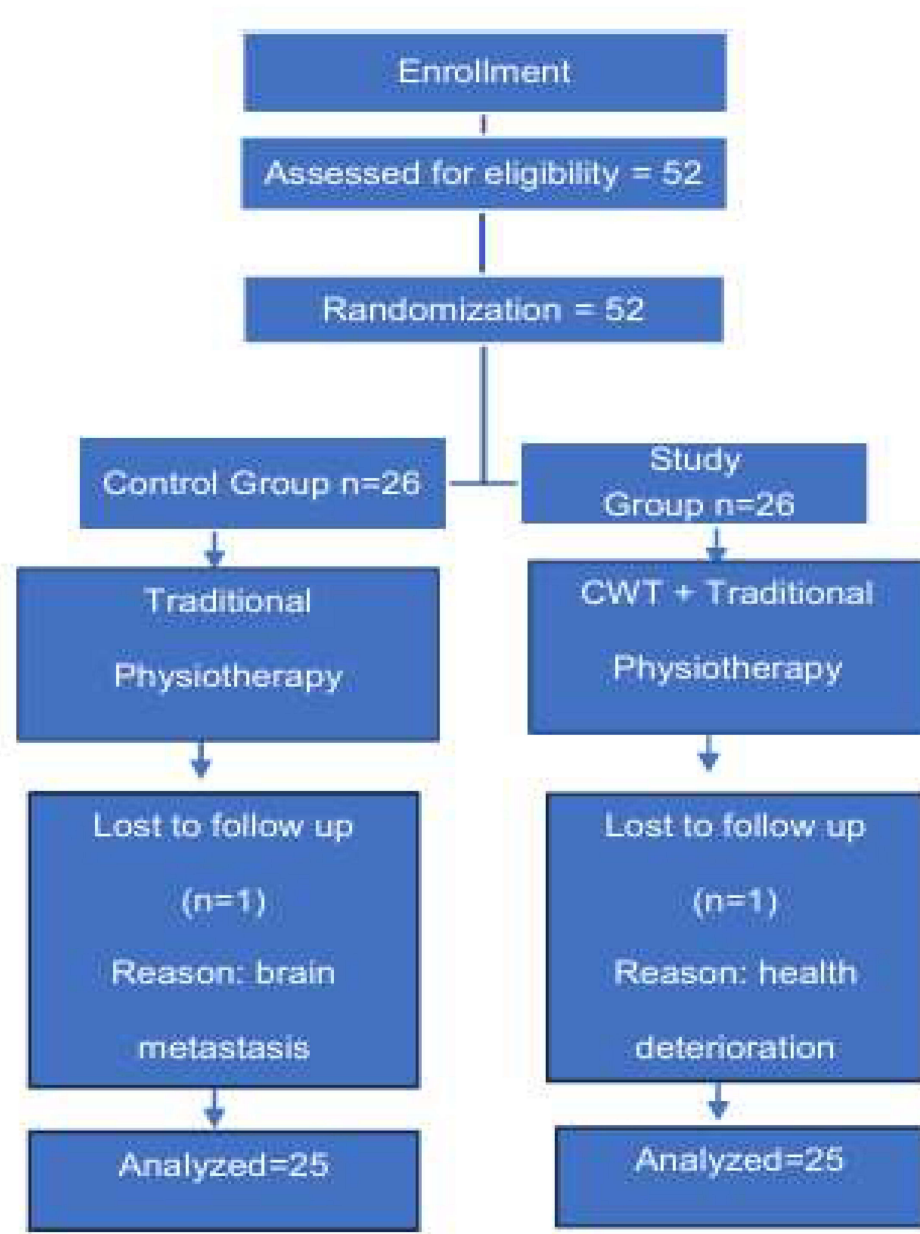


Figure 1 CONSORT flow diagram illustrates the progress of participants through each phase of the randomized controlled trial, including enrollment, allocation, follow-up, and analysis.

traditional physiotherapy program three times a week for eight weeks; while the control group comprised 25 patients who received their physical therapy traditional program only, 3 times/week for 8 weeks (Figure 1).

Measurement Procedures

Every patient filled out their medical history, comprising their name, age, residence, height, weight, and body mass index (BMI). Measurements were conducted before the trial started and eight weeks after treatment. Throughout management, all patients were told to document any adverse consequences. All patients were made aware of the evaluation and treatment processes before the study's commencement to foster their cooperation and confidence throughout the trial. The outcome assessor was blinded to group allocation to minimize assessment bias and ensure objective data collection.

Assessment Procedures

12-Item Short Form Survey (SF-12)

It is a commonly utilized screening tool to evaluate quality of life by assessing social, mental, and physical wellness.¹³ The HRQoL was evaluated via the Arabic version of the SF-12.¹⁴ It's reliable, easy-to-use, and valid.¹⁵

To guarantee clarity and understanding, the questionnaire was given out during in-person interviews. Each patient received a full explanation of the questionnaire's purpose and the meaning of each question before responding.

Responses were recorded verbally, and patients were reassured that their answers would remain confidential. The total SF-12 score was calculated based on the Physical Component Summary (PCS-12) and Mental Component Summary (MCS-12) scores, following standard scoring guidelines.

BIODEX Balance System SD (BBS)

Balance assessment was conducted using the Balance System SD (Model 950–441), manufactured by Biodex Medical Systems, Inc., Shirley, New York, USA. It comprises six practice modes and five testing procedures, enabling testing and practicing in static and dynamic contexts. The system's goals are to screen and condition the elderly for falling risk, measure balance for managing concussions, and provide weight-bearing training and testing for lower-limb injuries.¹⁶ Patients were assessed using three different test protocols:

Postural Stability Test (PST)

It was utilized to test static balance by measuring postural sway while the patient stands on a stable platform. Patients were instructed to maintain balance for 20 seconds while minimizing movement. The Overall Stability Index (OSI) was recorded, with higher values indicating poorer balance.

Limits of Stability Test (LoS)

It was utilized to evaluate dynamic balance by measuring the ability to shift weight in multiple directions. Patients were required to move a cursor (controlled by body movement) toward eight target zones on the screen without overshooting. The Directional Control (%) was recorded, representing movement accuracy.

Athlete's Single Leg Stability Test (ASLST)

Measures unilateral balance under progressive instability. Patients stood on a single leg while the platform's stability level gradually decreased. The Single-Leg Stability Score was recorded, with lower scores indicating better stability.

Testing Procedure

Patients performed each test three times, with a 30-second rest between trials. All tests were conducted barefoot, with foot placement standardized using Biodex guidelines. Analysis was done using the average score from three trials.

Outcome Measures & Data Analysis

The Biodex software automatically calculated OSI, Directional Control, and Single-Leg Stability Scores. Higher OSI values indicated greater postural instability, while higher Directional Control (%) and Stability Scores reflected better balance performance.

Handheld Dynamometer (HHD)

The Lafayette Model-01165, Lafayette Instrument Company, Lafayette, Indiana, USA, was used in the study. The Lafayette Model-01165 and the Hoggan microFET2 were the HHDs that gave the most reliable results when measuring isometric power and strength, respectively, by peak force. The reliability study of peak force and RFD showed good to exceptional results (coefficients > 0.70) for all muscle groups when comparing intra-rater, inter-rater, and inter-device reliability.¹⁷ HHD is a quantitative, reliable, and valid technique for identifying changes in minimum muscular strength that affect bodily function.¹⁸

Muscles Tested in the Study

Middle Trapezius Muscle. Every patient was instructed to lie prone on a treatment table with their heads turned to one side for comfort. The arms are placed off the side of the table, with the shoulder abducted to approximately 90°. She was told to hold her arm in this position and not let the therapist push it forward.

Lower Trapezius Muscle. Every patient was instructed to lie prone on a treatment table with the arm elevated approximately 135° in the scapular plane (Y-position) and the elbow extended. She was told to hold her arm in this position and not let the therapist push it forward.

Teres Major Muscle. Every patient was instructed to lie prone on a treatment table with the arm at the side, shoulder internally rotated, and palm facing up. She was told to push her arm backward and inward such as putting her hand in her back pocket. Hold it there and do not let me push it out.

Latissimus Dorsi Muscle. Every patient was instructed to lie prone on a treatment table with the arm extended and adducted against the trunk, palm facing inward. She was told to push her arm back and down toward her side, hold it there, and do not let the therapist push it up.

Quadriceps Muscle. The patient sat at the edge of a treatment table with knees flexed to 90° and feet hanging freely. She was told to straighten her knee as much as possible. Hold it there and do not let me push it down.

Hamstring Muscle. Prone on a treatment table with the knee flexed to approximately 90°. The patient was instructed to bend her knee and not let the therapist straighten it.

Gluteus Maximus Muscle. The patient lay prone on a treatment table with the knee flexed to 90° to minimize hamstring involvement. She was told to lift her thigh toward the ceiling. Hold it there and do not let the therapist push it down.

Gluteus Medius Muscle. The patient lay on her side with the test leg on top, the hip slightly extended and externally rotated (to emphasize posterior fibers), and the knee extended. The bottom leg is flexed for stability. She was told to lift her leg up and slightly back. Hold it there and do not let the therapist push it down.

Dorsiflexor Muscles. The patient sat with their legs hanging off the edge of a treatment table. She was told to pull her foot up toward her shin. Hold it there and do not let the therapist push it down.

Plantar Flexor Muscles. The patient sat on a treatment table or chair with the ankle in a neutral position, feet flat on the floor, and knees flexed to 90°. She was told to push down like she was pressing a gas pedal. Hold it there and do not let the therapist push your foot up.

2-minute Step Test (TMST)

One of the numerous options for assessing exercise capacity that can be carried out with ease in nearly all settings is the TMST.¹⁹ The participants were told to stand with their knees up to a height midway between their patella and the iliac crest and to walk in place as quickly as they could for two minutes. The number of right-side steps of the qualifying heights accomplished in two minutes is the test's performance measure.²⁰

Interventions

Traditional Physical Therapy Program

All participants underwent a standardized eight-week physiotherapy program consisting of one session per day, three times per week, and supervised by licensed physiotherapists with at least three years of clinical experience in oncology and musculoskeletal rehabilitation. Each session (30–40 minutes) included passive and active mobilization exercises for the glenohumeral (GH) joint, such as active range of motion, pendulum exercises, posterior and caudal glides, wall-climbing, shoulder wheel movements, and capsular stretching (posterior, anterior, and inferior). Each exercise was performed in sets of 10 repetitions with appropriate hold and rest times.^{21,22}

Circuit Weight Training (CWT)

The Circuit Training protocol (Table 1) was performed as follows:

The control group received CWT, which includes wall push-ups, bridge on the floor, single leg bridge, bird dog, windshield wiper, march in place, ball squat, squat with an overhead press, reverse pendulum, jumping rope, and spinal twist.²³ To further support core activation and improve postural stability, the single deadlift was also added to the routine. The training started with a five-minute stretching and calisthenics warm-up, then CWT exercises for a relatively short

Table 1 Circuit Weight Training (CWT)

Exercise	Target Muscle Group	Position
Wall push-up	Pectoralis major, Triceps, Deltoids	Standing against a wall, push-up movement.
Bridging	Gluteus maximus, Hamstrings, Core	Supine, knees bent, lift hips.
Single Leg Bridging	Gluteus maximus, Hamstrings, Core	Supine, lift one leg while bridging.
Bird dog	Core stabilizers, Multifidus, Gluteals	Quadruped, extend one arm and the opposite leg.
Windshield wiper	Obliques, Core stabilizers	Supine, rotate bent knees side to side
March in place	Hip flexors, Core, Cardiovascular endurance	Standing, alternate knee lifts.
Ball Squat	Quadriceps, Gluteals, Hamstrings	Squat with an exercise ball against a wall.
Squat with an overhead press	Hip abductors, Gluteus medius, Core Muscles	Squat while pressing weights overhead.
Reverse Pendulum	Deltoids, Rotator Cuff, Shoulder Stabilizers	Supine, arm relaxed, gentle circular motion of the shoulder.
Single Deadlift	Gluteus maximus, gluteus medius and minimus, hamstrings, erector spinae, core muscles, quadriceps, and calves.	Standing on one leg with a slight knee bend, hinging at the hips with a flat back, extending the free leg backward, keeping the hips square, and maintaining a straight line from head to heel.
Jumping Rope	Lower limb muscles, Cardiovascular endurance	Rhythmic jumps over a rope.
Spinal Twist	Erector Spinae, Obliques	Rotate torso side to side.

duration of 20 minutes, and a 10-minute walk/jog/cycle exercise. Number of circuits in each session: 2 circuits. Total time of each circuit training session: 30–35 minutes, performed 3 times per week.²³

Four functional exercises are completed, followed by an aerobic interval. Five minutes are spent on aerobic exercise. Every exercise was completed in 30 seconds, followed by a rest of thirty seconds before moving on to the next one. During training, patients are advised to breathe freely and refrain from using the Valsalva technique. It was advised that participants practice at a moderate intensity (they could speak but not sing). Intensity was adjusted based on patient response. Supervising physiotherapist monitored each session and modified the training load based on individual tolerance, fatigue, discomfort, or abnormal clinical signs. Adjustments included slowing the pace, extending rest intervals, or substituting exercises. If a patient was unable to perform an exercise safely or effectively despite modifications, the activity was discontinued for that session to prioritize patient safety.

Compliance was monitored through daily attendance logs, and missed sessions were recorded with reasons. Physiotherapists also documented exercise progression and any adverse events or limitations during training.

Statistical Analysis

An unpaired *t*-test was applied to compare subject characteristics across groups. The Shapiro–Wilk test was utilized to verify that the data had a normal distribution. To check the group homogeneity, Levene’s test for homogeneity of variances was employed. A two-way mixed MANOVA was conducted to compare the effects of each group on SF-12, TMST, LOS, Postural Stability, SLS, and muscle strength. Bonferroni corrections were made for the multiple comparisons that followed. For every statistical analysis, the significance level was established at $p < 0.05$. The statistical package for social sciences (SPSS) version 25 for Windows (IBM SPSS, Chicago, IL, USA) was employed for all statistical analyses.

Results

Participant Characteristics

As shown in Table 2, baseline characteristics were comparable between the study and control groups. There were no significant differences in age or BMI ($p > 0.05$).

Health-Related Quality of Life (SF-12) and Functional Capacity

At baseline, there were no significant differences between groups in either the Mental Component Summary (MCS) or Physical Component Summary (PCS) of the SF-12 questionnaire, or functional capacity measured by the 2-minute step test (TMST) ($p > 0.05$). After the intervention, the study group demonstrated significant improvements across all domains. MCS by 49.82% (from 33.40 ± 7.51 to 50.04 ± 9.01 , $p < 0.05$), PCS increased by 50.33% (from 31.85 ± 4.58 to 47.88 ± 7.01 , $p < 0.05$), and Functional performance also improved, with TMST scores increasing by 36.50% (from 40.88 ± 10.62 to 55.80 ± 10.38 steps/min, $p < 0.05$). In contrast, the control group showed no meaningful changes in MCS or PCS ($p > 0.05$) and a significant decline in TMST by 11.07%, (from 40.84 ± 10.73 to 36.32 ± 8.93 steps/min, $p < 0.05$).

Between-group comparisons revealed that post-treatment PCS, MCS, and TMST values were all significantly superior in the study group compared to the control group ($p < 0.05$), As shown in Table 3.

Balance Performance

At baseline, both groups had comparable scores in postural stability, limits of stability, and single-leg stability tests ($p > 0.05$).

Table 2 Comparison of Subject Characteristics Between Study and Control Groups

	Study Group	Control Group	MD	t-value	p-value
Age (years)	43.48 ± 6.03	43.80 ± 4.96	-0.32	-0.21	0.84
BMI (kg/m^2)	28.00 ± 2.60	27.61 ± 2.38	0.39	0.56	0.57

Abbreviations: MD, Mean difference; p value, Probability value.

Table 3 Mean MCS and PCS of SF-12 and TMST Before and After Treatment of Both Groups

	Pre Treatment	Post Treatment	MD	% of Change	p value
	Mean \pm SD	Mean \pm SD			
SF-12					
MCS					
Study group	33.40 ± 7.51	50.04 ± 9.01	-16.64	49.82	0.001*
Control group	34.35 ± 8.39	31.28 ± 7.52	3.07	8.94	0.10
MD	-0.95	18.76			
	$p = 0.67$	$p = 0.001^*$			
		$d = 2.26$			

(Continued)

Table 3 (Continued).

	Pre Treatment	Post Treatment	MD	% of Change	p value
	Mean \pm SD	Mean \pm SD			
PCS					
Study group	31.85 \pm 4.58	47.88 \pm 7.01	-16.03	50.33	0.001*
Control group	30.72 \pm 4.53	32.13 \pm 4.79	-1.41	4.59	0.21
MD	1.13	15.75			
	$p = 0.38$	$p = 0.001^*$			
		$d = 2.63$			
TMST (steps/min)					
Study group	40.88 \pm 10.62	55.80 \pm 10.38	-14.92	36.50	0.001*
Control group	40.84 \pm 10.73	36.32 \pm 8.93	4.52	11.07	0.002*
MD	0.04	19.48			
	$p = 0.98$	$p = 0.001^*$			
		$d = 2.01$			

Note: *significant.

Abbreviations: SD, Standard deviation; MD, Mean difference; p value, Probability value; d, Effect size; SF-12, 12-Item short form Survey; MCS, Mental component summary; PCS, Physical component summary; TMST, 2-minute step test.

Regarding to BBS tests, the study group demonstrated significant decrease in in LOS by 38.18%, postural stability by 47.69%, and SLS by 49.67%, indicating enhanced neuromuscular control and postural adjustments, ($p < 0.05$).

Conversely, the control group showed no significant changes in any balance measure ($p > 0.05$). Between-group comparisons revealed significantly greater improvements in all balance outcomes in the study group compared with controls ($p < 0.05$), as shown in [Table 4](#).

Table 4 Mean LOS, Postural Stability and SLS Before and After Treatment of Both Groups

	Pre Treatment	Post Treatment	MD	% of Change	p value
	Mean \pm SD	Mean \pm SD			
LOS (sec)					
Study group	89.16 \pm 37.58	55.12 \pm 22.39	34.04	38.18	0.001*
Control group	87.92 \pm 35.70	84.24 \pm 28.21	3.68	4.19	0.46
MD	1.24	-29.12			
	$p = 0.91$	$p = 0.001^*$			
		$d = 1.14$			

(Continued)

Table 4 (Continued).

	Pre Treatment	Post Treatment	MD	% of Change	p value
	Mean \pm SD	Mean \pm SD			
Postural stability (degrees)					
Study group	1.30 \pm 0.70	0.68 \pm 0.42	0.62	47.69	0.001*
Control group	1.33 \pm 0.67	1.37 \pm 0.51	-0.04	3.01	0.69
MD	-0.03	-0.69			
	$p = 0.87$	$p = 0.001^*$			
		$d = 1.47$			
SLS (degrees)					
Study group	7.51 \pm 3.18	3.78 \pm 2.69	3.73	49.67	0.001*
Control group	7.47 \pm 2.95	8.02 \pm 2.93	-0.55	7.29	0.12
MD	0.04	-4.24			
	$p = 0.96$	$p = 0.001^*$			
		$d = 1.51$			

Note: *significant.

Abbreviations: SD, Standard deviation; MD, Mean difference; p value, Probability value; d, Effect size; LOS, Limits of Stability Test; SLS, Single Leg Stability.

Muscle Strength

At baseline, no significant differences were found between the study and control groups across all muscle strength measures ($p > 0.05$).

Following the intervention, the study group demonstrated significant improvements in all tested muscles. Gains ranged from 12.87% in plantar flexors (8.86 ± 0.75 to 10.00 ± 0.96 kg, ($p < 0.05$)) to 19.79% in latissimus dorsi (7.58 ± 0.90 to 9.08 ± 0.87 kg, ($p < 0.05$)). Other marked increases included middle trapezius (14.98%), Lower trapezius (14.48%), Teres major (17.37%), Gluteus maximus (13.63%), Gluteus medius (15.59%), quadriceps (19.63%), hamstrings (14.60%), and Dorsiflexors (14.95%).

In contrast, the control group showed significant decreases in middle and lower trapezius, latissimus dorsi, gluteus medius, quadriceps, hamstrings, dorsiflexors, and plantar flexors strength ($p < 0.05$), while no significant changes were observed in teres major and gluteus maximus ($p > 0.05$).

Between-group comparisons confirmed that post-intervention muscle strength values were significantly higher in the study group compared with the control group across all tested muscles ($p < 0.05$), as shown in [Tables 5 and 6](#).

Discussion

This study aimed to evaluate how combined circuit weight training (CWT) affects postural stability, functional capacity, and muscular strength in breast cancer (BC) patients who underwent neoadjuvant chemotherapy. The findings demonstrated that, compared to the control group, the study group showed significant improvements in several areas, including SF-12 scores (both Mental Component Summary (MCS) and Physical Component Summary (PCS)), postural stability, limits of stability, single-leg stability tests, two-minute step tests, and muscle strength after 8 weeks of CWT ($p = 0.001$). These results suggest that combining CWT with traditional physical therapy programs yields greater benefits than conventional physical therapy alone.

Table 5 Mean Middle and Lower Trapezius, Teres Major, Latissimus Dorsi Gluteus Maximus, Gluteus Medius Strength Before and After Treatment of Both Groups

	Pre Treatment	Post Treatment	MD	% of Change	p value
	Mean \pm SD	Mean \pm SD			
Middle trapezius strength (kg)					
Study group	8.21 \pm 0.72	9.44 \pm 0.87	-1.23	14.98	0.001*
Control group	8.14 \pm 0.63	7.74 \pm 0.69	0.40	4.91	0.007*
MD	0.07	1.70			
	$p = 0.74$	$p = 0.001^*$			
		$d = 2.15$			
Lower trapezius strength (kg)					
Study group	7.94 \pm 0.82	9.09 \pm 0.66	-1.15	14.48	0.001*
Control group	7.64 \pm 0.84	7.37 \pm 0.88	0.27	3.53	0.03*
MD	0.30	1.72			
	$p = 0.21$	$p = 0.001^*$			
		$d = 1.51$			
Teres major strength (kg)					
Study group	8.06 \pm 1.09	9.46 \pm 0.97	-1.40	17.37	0.001*
Control group	7.83 \pm 1.38	7.52 \pm 1.35	0.31	3.96	0.09
MD	0.23	1.94			
	$p = 0.51$	$p = 0.001^*$			
		$d = 1.64$			
Latissimus dorsi strength (kg)					
Study group	7.58 \pm 0.90	9.08 \pm 0.87	-1.50	19.79	0.001*
Control group	7.50 \pm 1.31	7.16 \pm 1.36	0.34	4.53	0.02*
MD	0.08	1.92			
	$p = 0.79$	$p = 0.001^*$			
		$d = 1.68$			
Gluteus maximus strength (kg)					
Study group	8.88 \pm 0.82	10.09 \pm 1.04	-1.21	13.63	0.001*
Control group	8.68 \pm 1.21	8.42 \pm 1.27	0.26	3.00	0.16
MD	0.2	1.67			
	$p = 0.49$	$p = 0.001^*$			
		$d = 1.44$			
Gluteus medius strength (kg)					
Study group	8.66 \pm 0.93	10.01 \pm 1.03	-1.35	15.59	0.001*

(Continued)

Table 5 (Continued).

	Pre Treatment	Post Treatment	MD	% of Change	p value
	Mean \pm SD	Mean \pm SD			
Control group	8.73 \pm 1.13	8.26 \pm 1.02	0.47	5.38	0.003*
MD	-0.07	1.75			
	$p = 0.82$	$p = 0.001^*$			
		$d = 1.72$			

Note: *significant.

Abbreviations: SD, Standard deviation; MD, Mean difference; p value, Probability value; d, Effect size; kg, kilogram.

Table 6 Mean Quadriceps, Hamstring, Dorsiflexors, and Plantar Flexors Strength Before and After Treatment of Both Groups

	Pre Treatment	Post Treatment	MD	% of Change	p value
	Mean \pm SD	Mean \pm SD			
Quadriceps Strength (kg)					
Study group	8.76 \pm 0.83	10.48 \pm 1.27	-1.72	19.63	0.001*
Control group	8.56 \pm 1.23	7.96 \pm 1.23	0.60	7.01	0.001*
MD	0.2	2.52			
	$p = 0.51$	$p = 0.001^*$			
		$d = 2.02$			
Hamstring strength (kg)					
Study group	8.63 \pm 0.61	9.89 \pm 0.95	-1.26	14.60	0.001*
Control group	8.72 \pm 0.89	8.28 \pm 0.66	0.44	5.05	0.007*
MD	-0.09	1.61			
	$p = 0.65$	$p = 0.001^*$			
		$d = 1.96$			
Dorsiflexors strength (kg)					
Study group	8.76 \pm 0.65	10.07 \pm 0.87	-1.31	14.95	0.001*
Control group	8.89 \pm 1.27	8.49 \pm 1.25	0.40	4.50	0.007*
MD	-0.13	1.58			
	$p = 0.65$	$p = 0.001^*$			
		$d = 1.46$			
Plantar flexor strength (kg)					
Study group	8.86 \pm 0.75	10.00 \pm 0.96	-1.14	12.87	0.001*
Control group	8.73 \pm 1.19	8.30 \pm 1.27	0.43	4.93	0.005*

(Continued)

Table 6 (Continued).

	Pre Treatment	Post Treatment	MD	% of Change	p value
	Mean \pm SD	Mean \pm SD			
MD	0.13	1.70			
	$p = 0.66$	$p = 0.001^*$			
		$d = 1.50$			

Note: *significant.

Abbreviations: SD, Standard deviation; MD, Mean difference; p value, Probability value; d, Effect size; kg, kilogram.

The study also aligns with existing literature supporting the efficacy of high-intensity exercise for enhancing muscle strength and combating fatigue. For example, Tabata et al (2019) highlighted that high-intensity exercise could improve blood flow and increase myokine release, which is crucial for cancer treatment recovery.²⁴ Similarly, Forti et al (2017) noted that resistance training, which is integral to CWT, helps lower inflammatory cytokines, a known issue in cancer survivors.²⁵

Lee and An (2024) found that high-intensity circuit training improves body composition and muscle strength in breast cancer survivors (BCS), further supporting the present study's findings.²⁶ Moreover, exercise during cancer treatment is safe and beneficial, reducing the risk of musculoskeletal injuries and improving overall physical performance.^{27,28}

The current findings also confirm that muscle-strengthening exercises enhance postural stability, which is crucial for fall prevention, as noted in a meta-analysis by Bula et al (2023) and Vollmers et al (2018).^{29,30} These studies emphasized the long-term effects of resistance exercises on postural control, which is essential for maintaining balance and mobility during cancer recovery. Furthermore, cardiovascular endurance training through CWT improves functional capacity³¹ and contributes to better quality of life (QoL) and mood enhancement.³²

Studies like Lin et al (2021) have emphasized the positive impact of integrated exercise programs, which combine aerobic, resistive, and flexibility training, on fitness during chemotherapy.³³ In contrast, Montero et al (2015) highlighted the cardiovascular benefits of CWT over conventional resistance training, indicating that CWT improves not only muscular strength but also cardiovascular endurance, which is often compromised during cancer treatments.³⁴

This study's findings also corroborate results from Patsou et al (2017) and Sun et al (2023), which showed that physical activity significantly improves psychological well-being in cancer patients.^{35,36} Furthermore, Ramirez-Velez et al (2021) and Kolden et al (2002) demonstrated that exercise positively affects anxiety, self-image, and overall emotional health.^{37,38} These studies also suggest that combining strength training with aerobic exercise may reduce anxiety and stress, which are commonly experienced by breast cancer survivors.³⁹

While this research provides useful insights, a number of limitations need to be acknowledged. The relatively small sample size may have reduced the statistical power and limited the ability to conduct subgroup analyses. The study also relied on self-reported oral data, which are subject to recall bias and may not always provide reliable estimates of participants' physical activity. Additionally, the recruitment of participants was restricted to one organization, the Baheya Foundation for Breast Cancer Early Diagnosis and Treatment. While this institution is one of the most prominent breast cancer care institutions in Egypt and serves a diverse patient population, the single-center design may restrict the generalizability of the findings to other settings or populations. Furthermore, the inclusion of only patients aged 50 years or younger limits the applicability of results to older breast cancer survivors, who may exhibit different physiological responses to exercise interventions. Future studies should aim to include larger, more diverse, and multi-center cohorts, incorporate objective outcome measures in addition to self-reported data, and extend the duration of follow-up to better establish the long-term effects of Circuit Weight Training in this population.

Conclusion

This study contributes to the growing body of evidence supporting exercise interventions in breast cancer recovery. Circuit Weight Training, when integrated with standard physiotherapy, significantly improves postural stability, muscle strength, functional capacity, and health-related quality of life. By advocating for the inclusion of resistance training in clinical guidelines and promoting tailored exercise programs, healthcare providers can empower patients to improve functional outcomes, reduce treatment-related adverse effects, and enhance overall well-being.

Abbreviations

ASLST, Athlete's Single Leg Stability Test; BC, breast cancer; BBS, BIODEX Balance System SD; BMI, body mass index; CWT, Circuit Weight Training; GH, glenohumeral; HHD, Handheld Dynamometer; HRQoL, health-related quality of life; LoS, Limits of Stability Test; MCS-12, Mental Component Summary; PCS-12, Physical Component Summary; PST, Postural Stability Test; OSI, Overall Stability Index; SF-12, 12-item Short Form Survey; TMST, 2-minute step test.

Data Sharing Statement

Further data could be shared upon reasonable request from the corresponding author.

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Disclosure

The authors report no conflicts of interest in this work.

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