



Impact of Structured Verbal Cueing during Multimodal Rehabilitation in Breast Cancer Survivors Undergoing Radiotherapy: A Retrospective Study

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Abstract Background: Breast cancer survivors frequently experience shoulder dysfunction, cancer-related fatigue and elevated physiological stress following surgery and radiotherapy, adversely affecting functional recovery and quality of life. Rehabilitation interventions play an important role in supportive cancer care and survivorship management. **Objective:** To retrospectively evaluate the association between structured verbal cueing during multimodal exercise rehabilitation and shoulder range of motion (ROM), cancer-related fatigue and salivary cortisol levels in breast cancer survivors undergoing radiotherapy. **Methods:** This retrospective cohort study reviewed the medical records of 34 female breast cancer survivors aged 35-45 years undergoing radiotherapy following surgical treatment. Participants were categorized into a Multimodal Exercise with Verbal Cueing Group (MMVG, n = 17) and a Multimodal Exercise without Verbal Cueing Group (MMWVG, n = 17). Both groups completed a 12-week supervised multimodal exercise rehabilitation program. Shoulder ROM, FACIT-F scores and salivary cortisol levels were assessed at baseline, 6 weeks and 12 weeks. Repeated-measures ANOVA was performed and effect sizes were expressed as partial eta squared (η^2). **Results:** Both groups demonstrated significant improvements over time. At 12 weeks, participants in the MMVG demonstrated greater improvements in shoulder flexion (148.82°; 95% CI: 147.76-149.89 vs. 126.94°; 95% CI: 125.87-128.01), FACIT-F scores (43.06; 95% CI: 42.35-43.77 vs. 32.18; 95% CI: 31.47-32.88) and salivary cortisol levels (18.00 ng/mL; 95% CI: 17.85-18.15 vs. 22.35 ng/mL; 95% CI: 22.20-22.49) compared with the MMWVG (all $p < 0.001$). Significant time \times group interactions were observed for shoulder ROM (partial $\eta^2 = 0.987-0.995$), FACIT-F scores (partial $\eta^2 = 0.890$) and salivary cortisol levels (partial $\eta^2 = 0.877$). **Conclusions:** Multimodal exercise rehabilitation was associated with improved functional and physiological outcomes. Structured verbal cueing was associated with greater improvements than multimodal exercise alone, although prospective randomized studies are required to confirm these findings.

Key Words Breast Cancer Survivors, Radiotherapy, Cancer-Related Fatigue, Shoulder Dysfunction, Supportive Care, Rehabilitation

INTRODUCTION

Breast cancer is the most commonly diagnosed malignancy among women worldwide, with approximately 2.3 million new cases and 685,000 deaths reported in 2022 [1]. Advances in early detection and treatment have improved survival, increasing the number of women living with long-

term complications that impair functional independence and quality of life [2]. Shoulder dysfunction is among the most prevalent sequelae, affecting 30-50% of survivors [3,4]. Restricted mobility results from surgical trauma, lymph node dissection, reconstructive procedures and radiation-induced fibrosis, while lymphedema, altered muscle activation and

scapular dyskinesia further limit upper limb function [3-6]. Radiation exposure to the shoulder complex has also been linked to long-term deficits in range of motion, pain and daily activity limitations [6].

Cancer-related fatigue is another common and distressing complication, reported in up to 70% of survivors. It is characterized by persistent physical, emotional and cognitive exhaustion disproportionate to activity and poorly relieved by rest, driven by neuroendocrine dysregulation, inflammatory responses and stress-mediated hormonal alterations, all of which hinder rehabilitation participation [7]. Exercise-based rehabilitation has consistently demonstrated benefits in improving quality of life and reducing fatigue. Multimodal programs integrating mobility, strengthening, flexibility and aerobic training effectively restore functional capacity and physiological responses while targeting shoulder impairments [8,9].

Structured verbal cueing, which provides real-time instructions, corrective feedback and motivational reinforcement during exercises, remains underexplored in oncologic rehabilitation. Evidence from other clinical contexts suggests that verbal cueing enhances motor learning, neuromuscular coordination, exercise adherence and performance [10,11]. Objective tools such as goniometric shoulder range of motion, FACIT-F fatigue scale and salivary cortisol levels allow reliable evaluation of functional and physiological outcomes [12].

Structured verbal cueing is grounded in established principles of motor learning, whereby external verbal feedback facilitates motor skill acquisition, movement accuracy and patient engagement through enhanced attentional focus and reinforcement of appropriate movement patterns. Verbal cues promote self-correction, improve neuromuscular coordination and encourage adherence to therapeutic exercise, all of which are essential for successful rehabilitation [10,11]. Previous studies have demonstrated that therapist-delivered feedback and behavioural reinforcement improve exercise performance, movement quality and functional recovery across musculoskeletal rehabilitation settings [10,12]. In oncology rehabilitation, supervised multimodal exercise programmes have been associated with improved physical function, reduced cancer-related fatigue and enhanced quality of life among breast cancer survivors [8,9]. Although the specific contribution of structured verbal cueing has not been extensively investigated in breast cancer rehabilitation, these findings provide a theoretical rationale for evaluating its potential role as an adjunct to multimodal rehabilitation programmes.

Although multimodal exercise rehabilitation has demonstrated effectiveness in improving physical function and reducing cancer-related fatigue among breast cancer survivors, the potential contribution of structured verbal cueing during rehabilitation remains insufficiently investigated. Verbal cueing may enhance motor learning, exercise performance, adherence and patient engagement, potentially leading to improved rehabilitation outcomes.

However, evidence regarding its effectiveness in breast cancer rehabilitation is limited. Therefore, this study aimed to retrospectively evaluate the effects of structured verbal cueing during multimodal exercise rehabilitation on shoulder range of motion, cancer-related fatigue and salivary cortisol levels in breast cancer survivors undergoing radiotherapy.

METHODS

Study Design and Ethical Considerations

This retrospective analytical study was conducted through a comprehensive review of physiotherapy and medical records of breast cancer survivors who underwent rehabilitation during radiotherapy. The retrospective design was selected to evaluate real-world clinical rehabilitation practices and their impact on functional and physiological outcomes. Because participants were classified according to the rehabilitation approach documented in routine clinical practice rather than randomized allocation, the possibility of selection bias and residual confounding cannot be excluded. The study was approved by the Institutional Scientific Review Board (Approval No: ISRB/064/05/2025/ISRB/PGSR/SCPT) and retrospectively registered at ClinicalTrials.gov (Identifier: NCT07367334). All procedures were conducted in accordance with the principles of the Declaration of Helsinki (2013 revision). Although prospective registration is not mandatory for retrospective observational studies, the study was registered to enhance transparency, facilitate public accessibility of the study protocol and promote adherence to principles of research reporting.

Patient confidentiality and anonymity were strictly maintained and the requirement for informed consent was waived due to the retrospective nature of the study in accordance with institutional ethical guidelines.

Study Population

Medical records of 34 female breast cancer survivors aged 35-45 years who underwent definitive surgical treatment followed by adjuvant radiotherapy were retrospectively reviewed.

Inclusion Criteria

Histopathologically confirmed breast cancer; completion of surgical treatment; ongoing radiotherapy; $\geq 50\%$ reduction in shoulder range of motion compared to the contralateral side; baseline salivary cortisol levels within normal morning reference range; participation in supervised physiotherapy sessions during the 12-week intervention period.

Exclusion Criteria

Severe cardiovascular, neurological or respiratory disorders; metastatic disease; active infection or systemic inflammatory conditions; recent breast reconstruction surgery; concurrent chemotherapy during the intervention; incomplete documentation of outcome measures.

The study population included patients with Stage I (23.5%), Stage II (55.9%) and Stage III (20.6%) breast cancer.

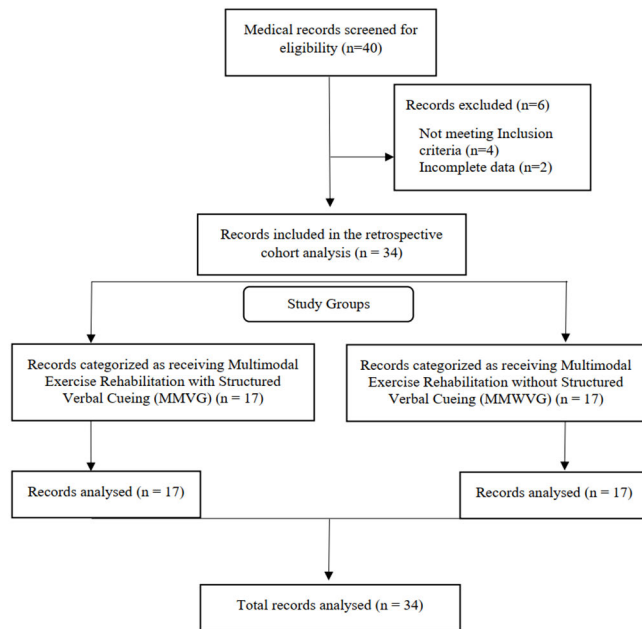


Figure 1: STROBE flow diagram illustrating the identification, screening, eligibility assessment, classification and analysis of medical records included in the retrospective cohort study.

Twenty-one participants (61.8%) had undergone modified radical mastectomy, while 13 (38.2%) had undergone breast-conserving surgery. Axillary lymph node dissection had been performed in 19 participants (55.9%) and 15 (44.1%) had undergone sentinel lymph node biopsy. All participants received external beam radiotherapy with a total prescribed dose of 50 Gy delivered in 25 fractions over five weeks. Common documented comorbidities included hypertension (14.7%) and diabetes mellitus (11.8%), whereas 73.5% of participants had no reported medical comorbidities.

Sample Size Calculation

An a priori sample size calculation was performed using G*Power (version 3.1.9.7; Franz Faul, Universität Kiel, Germany) for a repeated-measures analysis with two groups ($f = 0.40$, $\alpha = 0.05$, power = 0.95), yielding a minimum required sample size of 18 participants. Of the 40 records, 34 were eligible and included in the final analysis. were categorized into MMVG ($n = 17$) and MMWVG ($n = 17$) groups (Figure 1).

Although this study employed a retrospective cohort design, an a priori sample size calculation was performed to evaluate whether the available retrospective sample was adequate to detect clinically meaningful between-group differences in the primary outcome measure. The calculation was not used to determine participant recruitment but to assess the statistical adequacy of the available dataset for comparative analysis. Therefore, the results of the sample size estimation should be interpreted within the context of the retrospective study design.

Table 1: Structured rehabilitation protocol applied to both intervention groups

Phase	Duration	Activities
Warm-Up	5 minutes	Marching in place; Arm swings and ankle pumps; Neck and shoulder rolls
Aerobic Exercise	15-20 minutes	Walking based on individual progress and tolerance, Stationary cycling
Resistance Training	15-20 minutes	Bodyweight exercises: push-ups, squats, lunges; Resistance bands or light weights: biceps curls, shoulder press, leg extensions; Progression: Gradual increase in repetitions, sets or resistance as tolerated
Flexibility and stretching	5-10 minutes	Static stretching of shoulders, elbows, wrists, quadriceps, hamstrings and calf muscles; each stretch held for 15-30 seconds
Relaxation and Cool-Down	5 minutes	Deep breathing exercises; Ankle pumps; Neck and shoulder rolls

Randomization and Blinding

Randomization was not performed because of the retrospective observational design of the study. Participants were categorized based on documented rehabilitation records indicating whether structured verbal cueing was provided during exercise sessions. Blinding of participants and treating physiotherapists was not applicable. Data extraction and statistical analyses were performed using anonymised records to minimise potential assessment bias.

Procedure

Thirty-Four medical records were categorized into two groups based on documented therapist records of structured verbal cueing during exercise sessions. Both groups followed a 12-week multimodal exercise program, 3 sessions/week, 45-60 min/session (Table 1).

All participants underwent a 12-week multimodal exercise rehabilitation program, conducted three times per week, with each session lasting approximately 45-60 minutes. Medical records were categorized into the Multimodal Exercise with Verbal Cueing Group (MMVG, $n = 17$) and the Multimodal Exercise without Verbal Cueing Group (MMWVG, $n = 17$) based on documented therapist use of structured verbal cueing during rehabilitation sessions, which performed the same exercises without verbal cueing after initial demonstration.

Participants categorized to the Multimodal Exercise Rehabilitation with Structured Verbal Cueing Group (MMVG) received structured verbal cueing throughout each supervised rehabilitation session in addition to the standardized multimodal exercise programme. Verbal cueing was delivered consistently before and during exercise performance to facilitate correct movement execution, improve motor control, reinforce appropriate movement patterns and enhance participant engagement. The verbal cues comprised instructional guidance for movement execution, postural correction, pacing, breathing and motivational reinforcement. Typical instructional cues included reminders to perform movements within a comfortable range, maintain appropriate shoulder and

scapular alignment, avoid compensatory trunk movements and execute exercises in a slow and controlled manner. Participants also received positive reinforcement and corrective feedback throughout each session to encourage adherence, optimize movement quality and promote confidence during rehabilitation. The content, sequence and progression of verbal cueing were standardized across all rehabilitation sessions and integrated with the exercise programme to ensure consistency of intervention delivery.

All rehabilitation sessions were conducted by licensed physiotherapists with clinical experience in oncology rehabilitation. Prior to commencement of the study, therapists were oriented to the standardized rehabilitation protocol and verbal cueing procedures to ensure uniform implementation of the intervention. The same exercise protocol, progression criteria and verbal cueing strategy were applied throughout the 12-week rehabilitation programme. Outcome assessments were performed according to standardized departmental procedures to minimize variability in data collection.

Exercise adherence was monitored using rehabilitation attendance records maintained as part of routine clinical documentation. Participants who attended at least 80% of the scheduled supervised sessions were considered adherent to the rehabilitation programme.

The exercise program included warm-up, aerobic, resistance, flexibility/stretching and relaxation/cool-down phases, as detailed in Table 1 and was designed according to evidence-based multimodal exercise guidelines for breast cancer rehabilitation [8-11].

Outcome Measures

Outcome measures were extracted from standardized physiotherapy records at baseline, 6th week and 12th week:

Shoulder Range of Motion (ROM)

Assessed with a universal goniometer (flexion, abduction, external rotation) following standardized positioning protocols to ensure reliability and reproducibility.

Cancer-Related Fatigue

Measured using the FACIT-F scale, a validated instrument for quantifying fatigue severity in oncology populations.

Salivary Cortisol Levels

Physiological stress response evaluated via morning salivary cortisol levels analysed using ELISA.

All measurements were performed by trained physiotherapists and data were cross-checked to minimize errors. Repeated measurements at multiple time points enhance accuracy, reliability and the ability to track progression over time.

Statistical Analysis

Data were analysed using IBM SPSS Statistics version 27.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean±standard deviation. Normality of

distribution was assessed using the Shapiro-Wilk test. A two-way repeated measures ANOVA (RM-ANOVA) was conducted with time (baseline, 6th week and 12th week) as the within-subject factor and group (Multimodal Exercise with Structured Verbal Cueing [MMVG] vs. Multimodal Exercise without Verbal Cueing [MMWVG]) as the between-subject factor.

Mauchly's test assessed sphericity; the Greenhouse-Geisser correction was applied if the assumption was violated. Significant main and interaction effects were explored with Bonferroni-adjusted pairwise comparisons. Effect sizes were reported using partial eta squared (η^2) and statistical significance was set at $p < 0.05$.

As this was a retrospective observational study, statistical analyses were performed to evaluate associations between rehabilitation approaches and outcomes. Although baseline comparability was assessed, residual confounding arising from unmeasured clinical variables cannot be completely excluded.

RESULTS

Participant Characteristics

This retrospective cohort study evaluated the association between Multimodal Exercise Rehabilitation with Structured Verbal Cueing (MMVG) and changes in shoulder range of motion, cancer-related fatigue and salivary cortisol levels among female breast cancer survivors aged 35-45 years undergoing radiotherapy following surgical treatment.

A total of 40 medical records were screened for eligibility, of which six were excluded due to not meeting inclusion criteria ($n = 4$) or incomplete data ($n = 2$), resulting in 34 participants included in the final analysis. Seventeen participant records were categorized into the Multimodal Exercise Rehabilitation with Structured Verbal Cueing Group (MMVG) and 17 into the Multimodal Exercise Rehabilitation without Verbal Cueing Group (MMWVG) based on documented rehabilitation records.

Baseline demographic and clinical characteristics were comparable between groups, indicating comparable baseline characteristics between the study groups prior to rehabilitation. At baseline, mean shoulder flexion was $88.76 \pm 2.14^\circ$ (95% CI, 87.61-89.91) in MMVG and $87.47 \pm 1.55^\circ$ (95% CI, 86.55-88.39) in MMWVG ($p = 0.051$). Mean shoulder abduction was $83.88 \pm 2.64^\circ$ (95% CI, 82.37-85.39) versus $83.47 \pm 1.77^\circ$ (95% CI, 82.48-84.45) ($p = 0.597$) and external rotation was $41.82 \pm 1.94^\circ$ (95% CI, 40.63-43.02) versus $41.53 \pm 1.66^\circ$ (95% CI, 40.44-42.63) ($p = 0.639$). Baseline FACIT-Fatigue scores were 25.94 ± 1.14 (95% CI, 25.24-26.63) in MMVG and 25.82 ± 1.02 (95% CI, 25.15-26.49) in MMWVG ($p = 0.753$). Mean salivary cortisol levels were 26.49 ± 0.51 ng/mL (95% CI, 26.21-26.78) in MMVG and 26.59 ± 0.39 ng/mL (95% CI, 26.35-26.84) in MMWVG ($p = 0.528$). Independent t-tests confirmed no significant baseline differences across all outcomes.

Table 2: Comparison of shoulder range of motion between groups across time

Outcome	Time Point	MMVG (n = 17), Mean±SD (°)	MMWVG (n = 17), Mean±SD (°)	Mean Difference (95% CI)	p value
Shoulder Flexion	Baseline	88.76±2.14	87.47±1.55	1.29 (-0.01 to 2.59)	0.051
	6th Week	120.65±2.73	107.12±2.73	13.53 (12.18 to 14.88)	<0.001
	12th Week	148.82±2.16	126.94±2.16	21.88 (20.81 to 22.95)	<0.001
Shoulder Abduction	Baseline	83.88±2.64	83.47±1.77	0.41 (-0.96 to 1.78)	0.597
	6th Week	114.65±2.73	102.12±2.73	12.53 (11.18 to 13.88)	<0.001
	12th Week	143.88±2.37	121.94±2.37	21.94 (20.77 to 23.12)	<0.001
External Rotation	Baseline	41.82±1.94	41.53±1.66	0.29 (-0.91 to 1.49)	0.639
	6th Week	57.41±1.75	51.53±1.75	5.88 (5.01 to 6.75)	<0.001
	12th Week	71.88±1.87	59.53±1.87	12.35 (11.42 to 13.28)	<0.001

Repeated-measures ANOVA: Time × Group interaction: Shoulder flexion: $F = 2508.30$, $p < 0.001$, partial $\eta^2 = 0.987$; Shoulder abduction: $F = 2938.07$, $p < 0.001$, partial $\eta^2 = 0.989$; Shoulder external rotation: $F = 6394.94$, $p < 0.001$, partial $\eta^2 = 0.995$

Table 3: Comparison of FACIT-Fatigue scores between groups across time

Time Point	MMVG (n = 17)	MMWVG (n = 17)	Mean Difference (95% CI)	p value
Baseline	25.94±1.14	25.82±1.02	0.12 (-0.63 to 0.87)	0.753
6th Week	36.06±1.26	30.00±1.26	6.06 (5.44 to 6.68)	<0.001
12th Week	43.06±1.43	32.18±1.43	10.88 (10.17 to 11.59)	<0.001

Repeated-measures ANOVA: Time × Group interaction: $F = 260.20$, $p < 0.001$, partial $\eta^2 = 0.890$

Table 4: Comparison of salivary cortisol levels between groups across time

Time Point	MMVG (n = 17)	MMWVG (n = 17)	Mean Difference (95% CI)	p value
Baseline	26.49±0.51	26.59±0.39	-0.10 (-0.39 to 0.18)	0.528
6th Week	20.91±0.24	23.11±0.24	-2.21 (-2.33 to -2.09)	<0.001
12th Week	18.00±0.30	22.35±0.30	-4.35 (-4.50 to -4.20)	<0.001

Repeated-measures ANOVA: Time × Group interaction: $F = 227.41$, $p < 0.001$, partial $\eta^2 = 0.877$

Between-Group Comparison of Shoulder Range of Motion

Both study groups demonstrated progressive improvements in shoulder range of motion over the 12-week rehabilitation period. Participants in the MMVG consistently demonstrated greater improvements than those in the MMWVG across all assessment time points (Table 2).

Shoulder flexion in MMVG increased from $88.76 \pm 2.14^\circ$ at baseline to $120.65 \pm 0.66^\circ$ (95% CI, 119.30-121.99) at 6 weeks and $148.82 \pm 0.52^\circ$ (95% CI, 147.76-149.89) at 12 weeks, compared with $87.47 \pm 1.55^\circ$ to $107.12 \pm 0.66^\circ$ (95% CI, 105.77-108.46) and $126.94 \pm 0.52^\circ$ (95% CI, 125.87-128.01) in MMWVG, with significant between-group differences at both 6 and 12 weeks ($p < 0.001$). Repeated-measures ANOVA revealed a significant time × group interaction ($F = 2508.30$, $p < 0.001$, partial $\eta^2 = 0.987$).

Shoulder abduction increased from $83.88 \pm 2.64^\circ$ to $114.65 \pm 0.66^\circ$ (95% CI, 113.30-115.99) and $143.88 \pm 0.58^\circ$ (95% CI, 142.71-145.06) in MMVG, compared with $83.47 \pm 1.77^\circ$ to $102.12 \pm 0.66^\circ$ (95% CI, 100.77-103.46) and $121.94 \pm 0.58^\circ$ (95% CI, 120.77-123.12) in MMWVG ($p < 0.001$, $F = 2938.07$, partial $\eta^2 = 0.989$).

Shoulder external rotation similarly increased from $41.82 \pm 1.94^\circ$ to $57.41 \pm 0.43^\circ$ (95% CI, 56.55-58.28) at 6 weeks and $71.88 \pm 0.45^\circ$ (95% CI, 70.96-72.81) at 12 weeks in MMVG, versus $41.53 \pm 1.66^\circ$ to $51.53 \pm 0.43^\circ$ (95% CI, 50.66-52.40) and $59.53 \pm 0.45^\circ$ (95% CI, 58.61-60.45) in MMWVG ($p < 0.001$, $F = 6394.94$, partial $\eta^2 = 0.995$).

The assumptions for repeated-measures ANOVA were evaluated prior to analysis. Mauchly's test of sphericity was performed for all repeated outcome measures and where the assumption of sphericity was violated, Greenhouse-Geisser corrected results were interpreted. The observed time × group interactions remained statistically significant following correction.

Between-Group Comparison of FACIT-Fatigue scores

FACIT-F scores increased progressively in both study groups, indicating reduced cancer-related fatigue over time. Participants in the MMVG demonstrated greater improvements than those in the MMWVG at both follow-up assessments (Table 3). MMVG scores increased from 25.94 ± 1.14 at baseline to 36.06 ± 0.31 (95% CI, 35.44-36.68) at 6 weeks and 43.06 ± 0.35 (95% CI, 42.35-43.77) at 12 weeks, while MMWVG improved from 25.82 ± 1.02 to 30.00 ± 0.31 (95% CI, 29.38-30.62) and 32.18 ± 0.35 (95% CI, 31.47-32.88), with between-group differences at 6 and 12 weeks remaining statistically significant ($p < 0.001$, $F = 260.20$, partial $\eta^2 = 0.890$).

Between-Group Comparison of salivary cortisol levels

Salivary cortisol concentrations decreased progressively in both study groups throughout the rehabilitation period, with larger reductions observed in the MMVG than in the MMWVG (Table 4). MMVG showing reductions from 26.49 ± 0.51 ng/mL at baseline to 20.91 ± 0.06 ng/mL (95% CI, 20.79-21.02) at 6 weeks and 18.00 ± 0.07 ng/mL (95% CI, 17.85-18.15) at 12 weeks. Corresponding MMWVG levels decreased from 26.59 ± 0.39 ng/mL to 23.11 ± 0.06 ng/mL (95% CI, 22.99-23.23) and 22.35 ± 0.07 ng/mL (95% CI, 22.20-22.49), with significant between-group differences at both follow-ups ($p < 0.001$, $F = 227.41$, partial $\eta^2 = 0.877$).

Bonferroni-Adjusted Pairwise Comparisons of Outcome Measures Within Each Group

Within-group Bonferroni-adjusted pairwise comparisons confirmed significant progressive improvements across all time points in both groups for all outcomes.

In MMVG, shoulder flexion increased by 31.88° from baseline to 6 weeks, 28.18° from 6 to 12 weeks and 60.06° overall; shoulder abduction improved by 30.77° , 29.24° and 60.00° , while external rotation increased by 15.59° , 14.47°

and 30.06°. FACIT-F scores improved by 10.12, 7.00 and 17.12 points and salivary cortisol levels decreased by 5.58, 2.91 and 8.49 ng/mL over the respective intervals.

In MMVVG, shoulder flexion increased by 19.65°, 19.82° and 39.47°; shoulder abduction improved by 18.65°, 19.82° and 38.47°; external rotation increased by 10.00°, 8.00° and 18.00°; FACIT-F scores improved by 4.18, 2.18 and 6.35 points; and salivary cortisol decreased by 3.48, 0.77 and 4.24 ng/mL. These findings indicate that both rehabilitation approaches were associated with progressive improvements across the study period. However, participants receiving multimodal exercise rehabilitation with structured verbal cueing demonstrated consistently greater improvements in functional, fatigue and physiological outcomes than those receiving multimodal exercise rehabilitation without structured verbal cueing.

DISCUSSION

Breast cancer survivors frequently experience long-term shoulder dysfunction following surgery, lymph node dissection and radiotherapy, which can substantially impair activities of daily living, upper-limb function and overall quality of life. In the present study, both the standard multimodal exercise group (MME) and the multimodal exercise with structured verbal cueing group (MMVG) demonstrated significant improvements in shoulder range of motion at six and twelve weeks. Notably, the MMVG group exhibited greater gains in flexion (148.82° versus 126.94°), abduction (143.88° versus 121.94°) and external rotation (71.88° versus 59.53°) at twelve weeks, with large effect sizes (partial $\eta^2 > 0.98$, $p < 0.001$). These findings align with prior evidence that supervised multimodal physiotherapy and early rehabilitation interventions enhance shoulder mobility and reduce disability in breast cancer survivors [12-16]. The greater improvements observed among participants receiving structured verbal cueing may be associated with enhanced exercise performance, improved movement execution and greater engagement during supervised rehabilitation, thereby supporting functional recovery throughout breast cancer survivorship. However, these observations should be interpreted cautiously because of the retrospective cohort design.

Cancer-related fatigue is one of the most common and distressing symptoms experienced by breast cancer survivors, often persisting beyond active treatment and negatively affecting physical functioning, emotional well-being and quality of life [17-21]. In this study, FACIT-Fatigue scores increased in both groups, indicating reduced fatigue, but the MMVG demonstrated significantly higher improvements at both six and twelve weeks (43.06 versus 32.18 at twelve weeks, $p < 0.001$; partial $\eta^2 = 0.890$). These findings are consistent with previous studies showing that multimodal exercise programs, including aerobic, strength and mind-body interventions, effectively reduce cancer-related fatigue and improve survivorship outcomes [8,18,21]. The greater improvements observed in the MMVG may be associated with increased participant

engagement, therapist feedback and perceived therapeutic support during supervised rehabilitation, which have previously been linked to improved adherence and reduced cancer-related fatigue [10,11,18].

Physiological stress, measured via salivary cortisol, is associated with neuroendocrine dysregulation, chronic inflammation and impaired quality of life among breast cancer survivors. Both groups in our study showed progressive reductions in cortisol levels over twelve weeks, with the MMVG achieving significantly greater reductions at six and twelve weeks (18.00 ng/mL versus 22.35 ng/mL at twelve weeks, $p < 0.001$; partial $\eta^2 = 0.877$). These findings support evidence that structured exercise interventions may favourably influence stress-related physiological responses and contribute to improved well-being during cancer recovery [22-25]. The greater reduction in salivary cortisol observed among participants receiving structured verbal cueing may be associated with enhanced therapist-patient interaction, increased exercise engagement and supportive guidance during rehabilitation. Nevertheless, unmeasured physiological and psychosocial factors may also have influenced cortisol responses [10,11,23].

These results align with prior studies showing that multimodal exercise interventions improve shoulder function and reduce fatigue in breast cancer survivors [8,9]. The present findings suggest that structured verbal cueing may be associated with greater improvements in functional recovery and participant engagement when incorporated into multimodal rehabilitation programmes. However, prospective randomized controlled studies are required to determine whether these associations represent causal effects [10,11].

Participants who received multimodal exercise rehabilitation with structured verbal cueing demonstrated greater improvements in shoulder mobility, cancer-related fatigue and physiological stress than those who received multimodal exercise rehabilitation alone. Although these findings support the potential role of structured verbal cueing as an adjunct to rehabilitation, the retrospective cohort design limits causal inference. As a simple, low-cost and easily implementable strategy, structured verbal cueing may be incorporated into routine physiotherapy practice while awaiting confirmation from prospective randomized controlled trials. Beyond statistical significance, the observed improvements in shoulder range of motion and fatigue may be clinically meaningful, as these outcomes are closely related to upper-limb function, independence in activities of daily living and overall quality of life among breast cancer survivors.

The strengths of this study include the direct comparison of two routinely implemented rehabilitation approaches in a real-world clinical setting, the use of validated functional (shoulder range of motion and FACIT-Fatigue) and physiological (salivary cortisol) outcome measures and repeated assessments at baseline, 6 weeks and 12 weeks to evaluate rehabilitation progress over time. The standardized multimodal rehabilitation programme

and structured verbal cueing protocol improved consistency in intervention delivery, while the inclusion of both objective and patient-reported outcome measures provided a comprehensive evaluation of rehabilitation outcomes. Furthermore, this study addresses an underexplored area in oncology rehabilitation by examining the potential association of structured verbal cueing with functional, fatigue-related and physiological outcomes among breast cancer survivors undergoing radiotherapy. Several limitations should be considered when interpreting these findings. First, the retrospective cohort design precludes causal inference and is susceptible to selection bias because participants were categorized according to documented clinical practice rather than randomized allocation. Second, although baseline demographic characteristics were comparable between study groups, some potentially important clinical variables, including disease stage, surgical procedure, radiotherapy characteristics and other unmeasured confounders, may have influenced rehabilitation outcomes and could not be fully controlled because of the retrospective design. Third, the study was conducted at a single centre with a relatively small sample size, limiting the generalizability of the findings. Fourth, the follow-up period was limited to 12 weeks, preventing assessment of long-term rehabilitation outcomes. Finally, although standardized rehabilitation protocols were followed, therapist-related factors and variations in participant adherence may have influenced the observed outcomes. Future prospective multicentre randomized controlled trials with larger sample sizes and longer follow-up are warranted to validate these findings.

CONCLUSIONS

In conclusion, this retrospective cohort study demonstrated that both multimodal exercise rehabilitation approaches were associated with improvements in shoulder range of motion, cancer-related fatigue and salivary cortisol levels among breast cancer survivors undergoing radiotherapy. Participants who received structured verbal cueing demonstrated greater improvements in functional and physiological outcomes than those who received multimodal exercise rehabilitation alone. These findings support the potential role of structured verbal cueing as a practical and low-cost adjunct to oncology rehabilitation. However, owing to the retrospective observational design, these findings should be interpreted as associative rather than causal. Future multicentre prospective randomized controlled trials with larger sample sizes and longer follow-up are warranted to confirm these findings and establish the effectiveness of structured verbal cueing in breast cancer rehabilitation.

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Ethical Statement

The study was approved by the Institutional Scientific Review Board (Approval No: ISRB/064/05/2025/ISRB/PGSR/SCPT).

Clinical Trial Registration

The study was retrospectively registered at ClinicalTrials.gov (Identifier: NCT07367334).

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