

Impact of pre-radiation physical therapy exercises on neck and shoulder dysfunction and quality of life in head and neck cancer survivors with reconstruction surgeries: A pilot study

Running title: Pre-radiation exercise therapy in head and neck cancer

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ABSTRACT

Background: Head and neck cancer (HNC) patients who undergo pectoralis major myocutaneous (PMMC) or deltopectoral (DP) flap reconstruction commonly develop progressive neck and shoulder dysfunction during the early postoperative period. Whether structured exercise therapy delivered before the start of adjuvant radiation can modify this trajectory has not previously been tested.

Aim: To evaluate the effects of a 10-day pre-radiation exercise therapy programme on neck and shoulder dysfunction and quality of life in HNC patients after flap reconstruction.

Materials and Methods: Fifteen postoperative HNC patients scheduled for adjuvant radiation therapy were recruited for an intervention (n = 15; conventional exercises). Treatment was delivered once daily for 10 days during the post-surgical, pre-radiation window. Outcomes comprised the Numeric Pain Rating Scale (NPRS), shoulder range of motion (ROM), manual muscle testing (MMT), scapulohumeral rhythm via digital inclinometry, the Neck Disability Index (NDI), the Shoulder Pain and Disability Index (SPADI), and the Functional Assessment of Cancer Therapy–Head and Neck (FACT-H&N). Assessments were performed at baseline and immediately after the 10-day programme.

Results: After the 10-day programme, the intervention arm reached lower pain scores (5.60 ± 0.83), greater shoulder flexion ($104.1^\circ \pm 13.6^\circ$) and abduction, improved scapular upward rotation (24.8°), lower NDI (32.5) and SPADI scores, and higher FACT-H&N values (94.1).

Conclusion: A 10-day pre-radiation course of pre radiation exercise therapy produced gains in pain, shoulder mobility, scapulohumeral coordination, neck and shoulder disability, and quality of life in HNC patients after flap reconstruction. These data support embedding structured exercise therapy within the pre-radiation care pathway.

Key words: Head and neck cancer, prehabilitation, exercise therapy, shoulder dysfunction, quality of life, exercise therapy

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INTRODUCTION

Head and neck cancers account for approximately 930,000 new diagnoses worldwide each year, with India bearing a disproportionate burden owing to the entrenched use of tobacco in both smoking and smokeless forms.^{1,2} Within the Indian setting, these malignancies represent nearly 30% of all cancer cases.³ A majority of affected individuals present at locally advanced stages and therefore require a combined approach of surgical resection, reconstruction, and adjuvant radiation therapy.⁴

The pectoralis major myocutaneous (PMMC) flap, first described by Ariyan in 1979, remains a workhorse pedicled option for large head and neck defects.^{5,6} Although the procedure is reliable, with success rates above 95%, harvesting the pectoralis major disrupts shoulder girdle biomechanics in a manner that does not resolve spontaneously.⁷ Prospective data have documented mean shoulder flexion and abduction deficits of 25° and 30° on the operative side, alongside strength reductions of 35-40%, which persist at 12 months in the absence of targeted rehabilitation.⁸ The

deltpectoral (DP) flap spares the pectoralis major itself but produces extensive anterior chest wall scarring that constrains shoulder mobility through cutaneous tethering and fascial contracture.^{9,10}

Neck dissection further aggravates these impairments. Even when nerve-sparing techniques are employed, electrophysiological evidence of spinal accessory nerve dysfunction has been reported in 57% of cases, producing trapezius weakness, scapular winging, and a restricted overhead arc.^{11,12} Adjuvant radiation introduces an additional layer of morbidity through radiation-induced fibrosis, driven by TGF- β 1-mediated myofibroblast activation and excessive collagen deposition.^{13,14} Longitudinal data show mean post-radiation deficits of 15° in flexion and 20° in abduction at 12 months in neck dissection cohorts, together with persistent elevations in pain.¹⁵

Taken together, these mechanisms help explain why 40–70% of long-term head and neck cancer survivors live with chronic neck and shoulder pain, with documented impairment in self-care (68%), occupational activities (72%), and recreational pursuits (81%).^{16,17}

Despite this well-described trajectory, rehabilitation in most clinical settings begins only after radiation has finished, by which time fibrosis is already entrenched and the tissue response to mobilization is blunted.¹⁸ The concept of prehabilitation, in which targeted intervention is delivered before an anticipated physiological insult, has demonstrated value in other oncological populations. In colorectal cancer, trimodal prehabilitation has yielded superior functional recovery and shorter inpatient stays than conventional postoperative care.^{19,20} For head and neck cancer, the three- to six-week interval between surgery and radiation offers a clinically meaningful therapeutic window: surgical tissues have healed sufficiently to tolerate exercise forces, while radiation-induced fibrosis has not yet been initiated.²¹

Despite this evidence base, no trial has examined a structured course of exercise therapy delivered during the pre-radiation period in HNC patients after flap reconstruction.

The present study was designed to address this gap. We aimed to determine whether a 10-day pre-radiation course of conventional exercises could limit neck and shoulder dysfunction and preserve quality of life in HNC patients after PMMC or DP flap reconstruction, as compared with conventional exercises alone.

MATERIALS AND METHODS

Study design and ethics

This pilot study was conducted at a tertiary cancer hospital in India. Ethical clearance was granted by the Institutional Ethics Committee, and the study was registered with the Clinical Trial Registry of India

CTRI/2025/09/095404. Written informed consent was obtained from every participant before enrolment.

Participants

Postoperative HNC patients aged 25–70 years who had undergone PMMC or DP flap reconstruction and were scheduled to commence adjuvant radiation were screened for eligibility. Inclusion required a healed surgical flap with no active complications and a planned radiation start date 3–6 weeks after surgery. Patients were excluded if they presented with severe cardiovascular, neurological, or musculoskeletal conditions contraindicating exercise therapy, pre-existing severe shoulder or neck dysfunction, advanced metastatic disease, infected flaps, or secondary suturing.

Sample size

Using a published prevalence of shoulder and neck dysfunction of 3.8%, a Z value of 1.96, and a desired margin of error of 10%, the minimum sample size was calculated as (n = 15 in total), with allowance for potential dropouts.

Recruitment

Twenty three patients were assessed for eligibility, of whom eight were excluded (three did not meet inclusion criteria, two declined to participate, and three were not contactable). The remaining 15 were recruited (n = 15). All participants completed the 10-day programme and were included in the analysis.

Interventions

Participants underwent a structured pre-radiation exercise therapy programme consisting of:

- Active range of motion exercises (shoulder flexion, abduction, internal and external rotation; cervical flexion, extension, side flexion, and rotation)
- Wall ladder exercises (shoulder flexion and abduction)
- Wand exercises (assisted shoulder flexion, abduction, and external rotation)
- Shoulder isometric exercises (flexors, abductors, extensors)
- Neck isometric exercises (cervical flexors, extensors, and side flexors)
- Scapular stabilization exercises (scapular retraction, elevation, depression, and scapular setting)

The programme was administered once daily for 10 consecutive days during the post-surgical, pre-radiation period. Each session lasted approximately 20 minutes and included 10 repetitions of each exercise.

FITT Principle

Frequency: Once daily for 10 consecutive days.

Intensity: Low to moderate intensity, performed within pain-free limits and according to patient tolerance.

Time: Approximately 20 minutes per session.

Type: Active range of motion exercises, active-assisted mobility exercises, isometric strengthening exercises, and scapular stabilization exercises.

Progression: Exercises were initiated within the available pain-free range and progressively advanced over the 10-day period by increasing shoulder and cervical movement range, improving movement quality, and gradually increasing isometric hold duration from 5 to 10 seconds as tolerated. Emphasis was placed on restoring shoulder mobility, enhancing scapular control, and improving muscular activation while maintaining proper posture.

Outcome measures

All outcomes were captured at two time points: baseline (pre-intervention) and day 10, corresponding to the end of the 10-day pre-radiation programme and immediately before the planned start of adjuvant radiation therapy.

Primary outcomes were neck disability (NDI; 0–100%, with higher scores indicating greater disability) and shoulder disability (SPADI; 0–100%, with higher scores indicating greater disability). Secondary outcomes were pain (NPRS; 0–10), shoulder flexion and abduction ROM (universal goniometer, degrees), shoulder flexor and abductor strength (Kendall MMT, grades 0–5), scapulohumeral rhythm (digital inclinometer, degrees of scapular upward rotation), and quality of life (FACT-H&N; 0–144, with higher scores indicating better status).

Statistical analysis

Data were analyzed in SPSS version 23.0. Continuous variables are presented as mean \pm SD. Within-group changes from baseline to day 10 were tested by paired-samples t-tests, and ordinal strength data were analyzed with the Wilcoxon signed-rank or Friedman test as appropriate. Statistical significance was set at $P < 0.05$.

RESULTS

Baseline characteristics

A total of 15 head and neck cancer survivors participated in the study. The mean age of the participants was 58.67 ± 11.15 years. Among them, 10 (66.7%) were males and 5 (33.3%) were females. The mean weight was 66.00 ± 16.33 kg, mean height was 1.62 ± 0.19 m, and mean body mass index (BMI) was 23.54 ± 4.15 kg/m². These baseline demographic and anthropometric characteristics are presented in Table

Pain (NPRS)

The mean pain score decreased from 7.067 ± 0.799 on Day 1 to 5.600 ± 0.828 on Day 10. Paired t-test analysis revealed a statistically significant reduction in pain following pre-radiation exercise therapy ($t = 6.205$, $p < 0.001$), indicating that the intervention was effective in reducing pain among head and neck cancer survivors.

Shoulder range of motion

The mean shoulder flexion improved from $69.933 \pm 26.364^\circ$ at baseline to $104.067 \pm 13.557^\circ$ on Day 10. Statistical analysis demonstrated a significant improvement in shoulder flexion following the intervention ($t = 6.697$, $p < 0.001$).

The mean shoulder abduction increased from $65.200 \pm 18.590^\circ$ on Day 1 to $99.267 \pm 8.730^\circ$ on Day 10. The improvement was statistically significant ($t = 7.545$, $p < 0.001$), suggesting enhanced shoulder mobility after exercise therapy.

Muscle strength

Shoulder Flexor Muscle Strength

At baseline, the majority of participants demonstrated a muscle strength grade of 2– (66.7%). Following the intervention, the distribution shifted towards higher grades, with 33.3% of participants achieving grade 3–, 26.7% achieving grade 3, and 13.3% achieving grade 2+ on Day 10. These findings indicate improvement in shoulder flexor muscle strength following pre-radiation exercise therapy.

Shoulder Abductor Muscle Strength

At baseline, most participants demonstrated a muscle strength grade of 2– (60.0%). On Day 10, muscle strength improved, with 40.0% of participants achieving grade 3–, 26.7% grade 2–, 20.0% grade 3, and 13.3% grade 2+. This shift toward higher muscle strength grades suggests improvement in shoulder abductor strength following intervention.

Scapulohumeral rhythm

The mean scapulohumeral rhythm increased from 15.067 ± 7.535 at baseline to 24.800 ± 6.889 on Day 10. This improvement was statistically significant ($t = 5.707$, $p < 0.001$), indicating better coordination between scapular and humeral movements following intervention.

Neck and shoulder disability

The mean Neck Disability Index score increased from 27.600 ± 6.780 on Day 1 to 30.467 ± 16.932 on Day 10. However, the difference was not statistically significant ($t = 0.621$, $p = 0.544$), suggesting that the intervention did not produce a significant change in neck-related disability during the study period.

The mean SPADI score decreased from 75.200 ± 11.730 at baseline to 67.267 ± 14.543 on Day 10. The reduction was statistically significant ($t = 4.513$, $p < 0.001$), indicating improvement in shoulder pain and functional disability following exercise therapy.

Quality of life (FACT-H&N)

The mean FACT-HN score increased from 84.667 ± 7.451 on Day 1 to 94.133 ± 5.436 on Day 10. Statistical analysis showed a significant improvement ($t = 6.370$, $p < 0.001$), suggesting that pre-radiation exercise therapy positively influenced the quality of life of participants.

DISCUSSION

Head and neck cancer survivors undergoing PMMC or DP flap reconstruction commonly experience postoperative pain, shoulder dysfunction, muscle weakness, altered scapular mechanics, and reduced quality of life due to surgical trauma, donor-site morbidity, neck dissection, and subsequent treatment-related complications. The period between surgery and initiation of adjuvant radiotherapy represents a unique therapeutic opportunity, as surgical tissues have healed sufficiently to tolerate exercise while radiation-induced fibrosis has not yet developed. The present study evaluated the effects of a structured 10-day exercise programme delivered during this postoperative, pre-radiation window and demonstrated significant improvements in pain, shoulder range of motion, muscle strength, scapulohumeral rhythm, shoulder disability, and quality of life.

A significant reduction in pain was observed following the intervention. Postoperative pain after flap reconstruction and neck dissection is often associated with tissue trauma, scar formation, muscular imbalance, restricted mobility, and altered shoulder biomechanics. Exercise therapy may contribute to pain reduction through improved tissue extensibility, restoration of normal movement patterns, enhanced circulation, and reduction of protective muscle guarding. Previous evidence has demonstrated that exercise-based rehabilitation improves symptom burden, physical functioning, and pain-related outcomes in head and neck cancer survivors receiving cancer treatment.^{18,22,24} However, persistent shoulder and neck pain despite rehabilitation has also been reported, particularly in individuals with accessory nerve dysfunction, severe surgical morbidity, or progressive treatment-related fibrosis.^{12,15} The favourable pain reduction observed in the present study may be attributed to the initiation of rehabilitation during the postoperative, pre-radiation period before the onset of radiation-induced fibrotic changes.

Significant improvements were observed in shoulder flexion and abduction following the intervention. Restoration of shoulder mobility is essential for activities of daily living, self-care, occupational performance, and overall functional independence. Previous studies have demonstrated that rehabilitation interventions can improve upper extremity function and reduce donor-site morbidity following PMMC flap reconstruction and neck dissection.^{7,8,25} The present findings support these observations and suggest that early exercise therapy may help restore shoulder mobility during the postoperative, pre-radiation phase. Nevertheless, previous evidence has also documented persistent movement restrictions following flap reconstruction despite rehabilitation,

largely due to scar tissue formation, fascial contracture, and soft tissue stiffness.^{10,12} The greater improvements observed in the present study may reflect the benefits of introducing rehabilitation before chronic restrictions and radiation-related fibrosis become established.

Improvements in shoulder flexor and abductor muscle strength were observed following the intervention. Muscle weakness following flap reconstruction may result from pectoralis major harvest, postoperative immobilization, pain, and spinal accessory nerve dysfunction. Exercise therapy may enhance neuromuscular activation, motor unit recruitment, and muscular endurance, thereby improving functional performance. Previous literature has demonstrated improvements in upper extremity function following rehabilitation programmes in head and neck cancer survivors.^{8,16,25} In contrast, persistent strength deficits have also been reported due to donor-site morbidity and accessory nerve impairment, even after rehabilitation.^{8,11} The positive changes observed in the present study suggest that exercise therapy delivered during the postoperative, pre-radiation window may facilitate early recovery before secondary treatment-related complications further compromise muscle function.

The present study demonstrated a significant improvement in scapulohumeral rhythm. Normal scapular motion depends on coordinated activation of the trapezius, serratus anterior, and rotator cuff musculature. Neck dissection and accessory nerve dysfunction may disrupt these mechanisms and contribute to scapular dyskinesis and impaired shoulder biomechanics. Previous evidence has shown that rehabilitation interventions can positively influence scapular stabilization and movement coordination in head and neck cancer survivors.^{15,16} However, persistent scapular dysfunction despite rehabilitation has also been reported, particularly when accessory nerve injury is severe.^{11,12} The improvements observed in the present study suggest that exercise therapy initiated during the postoperative, pre-radiation period may enhance shoulder biomechanics before radiation-related tissue changes occur.

No statistically significant improvement was observed in Neck Disability Index scores. The absence of significant change may be explained by the short duration of the intervention, ongoing tissue healing, postoperative precautions, and persistent cervical soft tissue restrictions. Previous studies have reported improvements in functional outcomes following structured exercise and prehabilitation programmes in head and neck cancer populations.^{18,26} At the same time, persistent neck dysfunction has been identified as a common long-term consequence of neck

dissection despite rehabilitation interventions.^{12,16} The findings of the present study suggest that a longer duration of rehabilitation extending throughout the radiation treatment period may be necessary to achieve clinically meaningful improvements in neck-related disability.

A significant reduction in SPADI scores was observed following intervention, indicating improvements in shoulder pain and functional disability. Reduced pain, improved mobility, increased muscle strength, and enhanced scapular mechanics likely contributed to these functional gains. Similar improvements in upper extremity function and reductions in donor-site morbidity following rehabilitation have been reported previously.^{7,25} However, persistent functional limitations may continue to occur in the presence of neural injury, severe postoperative impairments, or treatment-related complications.¹² The findings support the role of structured exercise therapy delivered during the postoperative, pre-radiation period in minimizing shoulder-related disability and promoting functional recovery.

Quality of life improved significantly following the intervention. Improvements in pain, physical function, shoulder mobility, and performance of daily activities may have contributed to enhanced overall well-being. Existing evidence has consistently demonstrated positive associations between exercise participation, physical functioning, and quality of life among head and neck cancer survivors.^{18,24,26,27} The present findings are consistent with these observations and suggest that rehabilitation initiated during the postoperative, pre-radiation window can positively influence patient-reported outcomes. However, long-term treatment-related impairments, including radiation fibrosis and neuromuscular complications, have been reported to negatively affect quality of life despite rehabilitation interventions.^{15,27} Therefore, longer follow-up studies are needed to determine whether the improvements observed in the present study can be sustained throughout and beyond radiotherapy.

Overall, the findings suggest that implementing a structured exercise programme during the postoperative, pre-radiation period may help optimize functional recovery before the onset of radiation-induced complications. Early rehabilitation appears to offer a valuable opportunity to address pain, mobility limitations, muscle weakness, and disability while improving quality of life in head and neck cancer survivors undergoing flap reconstruction.

LIMITATIONS

The study was limited by its small sample size, pre-post design without a control group, and short intervention duration of 10 days. Outcomes were assessed only immediately after treatment, and

objective biomechanical measures were not included. Variations in surgical procedures may have influenced individual responses to the intervention.

CONCLUSION

The present study demonstrated that a structured 10-day pre-radiation exercise therapy programme was effective in improving pain, shoulder range of motion, shoulder muscle strength, scapulohumeral rhythm, shoulder-related disability, and quality of life in head and neck cancer survivors following PMMC or DP flap reconstruction. Although no significant improvement was observed in neck disability, the overall findings suggest that early rehabilitation during the post-surgical, pre-radiation period can positively influence functional recovery and patient well-being. These results support the incorporation of structured exercise therapy into routine pre-radiation rehabilitation protocols for head and neck cancer patients.

FUTURE SCOPE

Further research with larger randomized controlled trials and longer follow-up is required to validate these findings. The inclusion of objective outcome measures and multicentre recruitment may enhance the generalizability and clinical relevance of pre-radiation rehabilitation in head and neck cancer survivors.

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TABLES

Table 1. Baseline demographic characteristics of participants.

Variable	Control (n = 15)	Intervention (n = 15)	t / χ^2	P
Age (years)	58.67 ± 11.15	52.67 ± 10.23	1.53 6	0.13 6
Sex (M/F)	10/5	9/6	0.14 4	1.00 0
Weight (kg)	66.00 ± 16.33	60.33 ± 15.60	0.97 2	0.34 0
Height (m)	1.62 ± 0.19	1.66 ± 0.09	0.60 0	0.55 3

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BMI (kg/m ²)	23.54 ± 4.15	22.54 ± 3.66	0.69 7	0.49 2
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Table 2. Outcome measures at baseline and at day 10 (end of the 10-day pre-radiation programme).

Outcome Measure	Pre-test Mean ± SD	Day 10 Mean ± SD	t-value	p-value
NPRS	7.067 ± 0.799	5.600 ± 0.828	6.205	<0.001*
Shoulder Flexion	69.933 ± 26.364	104.067 ± 13.557	6.697	<0.001*
Shoulder Abduction	65.200 ± 18.590	99.267 ± 8.730	7.545	<0.001*
Scapulohumeral Rhythm	15.067 ± 7.535	24.800 ± 6.889	5.707	<0.001*
Neck Disability Index	27.600 ± 6.780	30.467 ± 16.932	0.621	0.544
SPADI	75.200 ± 11.730	67.267 ± 14.543	4.513	<0.001*
FACT-HN	84.667 ± 7.451	94.133 ± 5.436	6.370	<0.001*

Values are mean ± SD where SD was available in the source data; single values are means. Em dashes (—) indicate timepoint values not separately reported in the source manuscript for this group/measure. NPRS = Numeric Pain Rating Scale; NDI = Neck Disability Index; SPADI = Shoulder Pain and Disability Index; FACT-H&N = Functional Assessment of Cancer Therapy–Head and Neck.

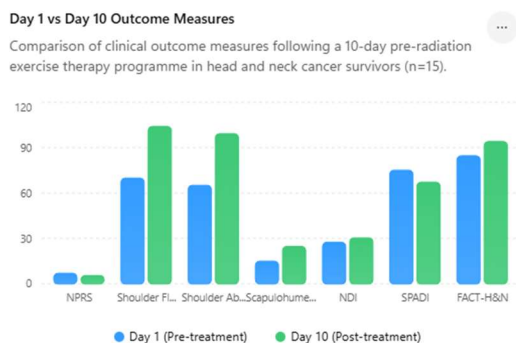


Figure I. Comparison of Day 1 (Pre-treatment) and Day 10 (Post-treatment) outcome measures following the 10-day pre-radiation exercise therapy programme.