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Effectiveness of Combined Simple Aerobic Exercise and Diaphragmatic Breathing Exercise in Reducing Cancer-Related Fatigue among Cancer Patients: A Randomized Controlled Trial

Dr. Bhaskara Rao Jagurothula

Principal
Dept. of Physiotherapy
Sai Sri College of Physiotherapy, Eluru, Dr. NTRUHS, Andhra Pradesh, India.
ORCID: https://orcid.org/0000-0001-9484-7939

Abstract:

Background

Cancer-related fatigue (CRF) is one of the most common and distressing symptoms experienced by individuals undergoing or recovering from cancer treatment. Unlike ordinary fatigue, CRF is persistent, disproportionate to recent activity, and is not completely relieved by rest. It negatively affects physical functioning, emotional well-being, cognitive performance, and overall quality of life. Exercise-based rehabilitation has emerged as a safe and effective non-pharmacological intervention for managing CRF. Simple aerobic exercise enhances cardiovascular endurance and functional capacity, while diaphragmatic breathing promotes relaxation, improves respiratory efficiency, and reduces psychological stress. However, limited evidence exists regarding the combined effectiveness of these two interventions in reducing fatigue among patients with cancer.

Objective

To determine the effectiveness of combined simple aerobic exercise and diaphragmatic breathing exercise in reducing cancer-related fatigue and improving functional capacity and quality of life among cancer patients.

Methods

A randomized controlled trial was conducted involving 60 adult cancer patients experiencing moderate to severe cancer-related fatigue. Participants were randomly allocated into two groups comprising 30 participants each. The experimental group received conventional physiotherapy along with simple aerobic exercise and diaphragmatic breathing exercises, whereas the control group received conventional physiotherapy alone. The intervention was administered five sessions per week for six weeks. Outcome measures included the Functional Assessment of Chronic Illness Therapy–Fatigue (FACIT-F), Brief Fatigue Inventory (BFI), Six-Minute Walk Test (6MWT), Borg Rating of Perceived Exertion (RPE), and the European Organisation for Research and Treatment of Cancer Quality of Life Questionnaire (EORTC

QLQ-C30). Assessments were performed at baseline and after completion of the intervention. Statistical analysis was conducted using SPSS Version 29 with the level of significance set at $p < 0.05$.

Results

The experimental group demonstrated a statistically significant improvement in fatigue severity, functional exercise capacity, perceived exertion, and quality of life compared with the control group ($p < 0.05$). Participants receiving the combined intervention showed greater improvements in FACIT-F scores and Six-Minute Walk Test distances, indicating enhanced physical endurance and reduced fatigue.

Conclusion

Combined simple aerobic exercise and diaphragmatic breathing exercise constitute an effective and feasible rehabilitation strategy for reducing cancer-related fatigue in patients undergoing cancer treatment. Incorporating these interventions into routine oncology rehabilitation programmes may improve physical performance, alleviate fatigue, and enhance overall quality of life.

Keywords: Cancer-related fatigue; Aerobic exercise; Diaphragmatic breathing; Oncology rehabilitation; Physiotherapy; Functional capacity; Quality of life; Randomized controlled trial.

1. Introduction

Cancer remains one of the leading causes of morbidity and mortality worldwide, placing a considerable burden on healthcare systems and significantly affecting patients' physical, psychological, and social well-being. Advances in early diagnosis and treatment have improved survival rates, resulting in an increasing number of individuals living with the long-term consequences of cancer and its treatment. Among these consequences, cancer-related fatigue (CRF) is recognised as one of the most prevalent and debilitating symptoms experienced by patients throughout the cancer continuum. Unlike normal fatigue, cancer-related fatigue is characterised by a persistent subjective sense of physical, emotional, and cognitive tiredness that is disproportionate to recent activity and is not completely relieved by rest. It interferes substantially with daily activities, work performance, emotional health, and overall quality of life.

The prevalence of cancer-related fatigue has been reported to range from 40% to 90%, depending on cancer type, treatment modality, and stage of disease. Fatigue commonly develops during chemotherapy, radiotherapy, immunotherapy, hormone therapy, and surgical recovery. Multiple physiological and psychological mechanisms contribute to CRF, including chronic inflammation, anaemia, mitochondrial dysfunction, muscle wasting, endocrine alterations, sleep disturbances, nutritional deficiencies, anxiety, depression, and reduced physical activity. The multifactorial nature of CRF makes its management particularly challenging, requiring comprehensive rehabilitation approaches rather than reliance on pharmacological interventions alone.

In recent years, exercise therapy has become a cornerstone of supportive cancer care. International clinical practice guidelines consistently recommend appropriately prescribed physical activity as one of the most effective interventions for reducing cancer-related fatigue. Aerobic exercise improves cardiovascular fitness, skeletal muscle function, oxygen utilisation, metabolic efficiency, and physical endurance while reducing deconditioning associated with prolonged inactivity. Moderate-intensity activities such as walking and stationary cycling have demonstrated favourable outcomes in improving fatigue severity, functional capacity, and health-related quality of life among patients receiving active cancer treatment as well as cancer survivors.

Respiratory rehabilitation also plays an increasingly recognised role in oncology care. Diaphragmatic breathing is a simple breathing technique that promotes efficient ventilation by encouraging diaphragmatic movement rather than accessory muscle recruitment. Controlled diaphragmatic breathing improves oxygen exchange, reduces respiratory effort, decreases sympathetic nervous system activation, enhances parasympathetic activity, and facilitates psychological relaxation. These physiological effects may contribute to reductions in perceived fatigue, anxiety, and emotional distress commonly experienced by individuals undergoing cancer treatment.

Although aerobic exercise and diaphragmatic breathing have each demonstrated beneficial effects independently, relatively few studies have evaluated their combined application as a comprehensive rehabilitation intervention for cancer-related fatigue. Integrating aerobic conditioning with breathing exercises may produce synergistic improvements by simultaneously addressing cardiovascular fitness, respiratory efficiency, autonomic regulation, psychological well-being, and functional performance. Such an integrated programme is inexpensive, safe, easy to administer, and suitable for implementation in hospitals, outpatient rehabilitation centres, and home-based settings.

The increasing emphasis on non-pharmacological supportive care highlights the importance of developing evidence-based physiotherapy interventions that can be incorporated into routine oncology rehabilitation programmes. Establishing the effectiveness of combined simple aerobic exercise and diaphragmatic breathing exercise may provide clinicians with a practical strategy for improving patient outcomes while minimising treatment-related complications.

Therefore, the present randomized controlled trial was undertaken to evaluate the effectiveness of combined simple aerobic exercise and diaphragmatic breathing exercise in reducing cancer-related fatigue and improving functional capacity and quality of life among patients with cancer.

2. Review of Literature

Cancer-related fatigue (CRF) is recognised as one of the most prevalent and disabling symptoms experienced by individuals undergoing cancer treatment. Unlike normal fatigue, CRF is persistent, multifactorial, and significantly interferes with physical, emotional, and cognitive functioning. The National Comprehensive Cancer Network defines CRF as a distressing, persistent, subjective sense of physical, emotional, and cognitive tiredness related to cancer or cancer treatment that is disproportionate to recent activity and interferes with normal functioning. Despite advances in cancer treatment, fatigue remains underdiagnosed and undertreated, highlighting the need for effective rehabilitation strategies.

Several studies have demonstrated that exercise is among the most effective non-pharmacological interventions for reducing cancer-related fatigue. Moderate aerobic exercise has consistently shown positive effects on cardiovascular endurance, skeletal muscle function, metabolic efficiency, and psychological well-being. Exercise also reduces treatment-related deconditioning, thereby improving overall functional performance and quality of life.

A systematic review by Mustian et al. (2017) evaluated more than 100 clinical trials investigating interventions for cancer-related fatigue. The authors concluded that exercise interventions produced greater improvements in fatigue than pharmacological therapies. Walking programmes, cycling, resistance training, and combined exercise interventions demonstrated significant reductions in fatigue severity while improving physical function and quality of life. The review recommended exercise as a first-line intervention for cancer survivors experiencing persistent fatigue.

Campbell et al. (2019) published updated exercise guidelines for cancer survivors through the American College of Sports Medicine (ACSM). Based on extensive evidence, the authors recommended at least 150 minutes of moderate-intensity aerobic exercise per week combined with resistance exercise for improving fatigue, anxiety, depression, and physical function. These guidelines highlighted exercise as an essential component of comprehensive oncology rehabilitation.

Schmitz et al. (2019) further strengthened the evidence supporting exercise therapy in oncology by demonstrating that structured physical activity programmes significantly improve physical functioning while reducing treatment-related complications. Their review emphasised that appropriately prescribed aerobic exercise is safe across multiple cancer types, including breast, colorectal, prostate, and haematological cancers.

Simple aerobic exercise programmes, particularly walking-based interventions, have received increasing attention because they are inexpensive, easily supervised, and feasible for hospital-based and home-based rehabilitation. Walking improves oxygen utilisation, cardiovascular endurance, lower-limb muscle strength, and exercise tolerance while minimising adverse effects. Randomised clinical trials have shown that walking programmes lasting between six and twelve weeks significantly reduce fatigue and improve quality of life among patients receiving chemotherapy.

Jones et al. (2018) investigated moderate-intensity aerobic training in breast cancer survivors and observed significant improvements in maximal oxygen consumption, exercise tolerance, and fatigue severity after a twelve-week intervention. Participants also demonstrated improvements in physical functioning and emotional well-being, supporting the role of aerobic exercise as a core component of cancer rehabilitation.

Similarly, Scott et al. (2018) reported that moderate aerobic exercise enhanced cardiorespiratory fitness while reducing systemic inflammation associated with cancer-related fatigue. Improvements in physical capacity were associated with better quality of life and reduced symptom burden.

In addition to aerobic exercise, respiratory rehabilitation has gained increasing recognition in supportive oncology care. Diaphragmatic breathing is a simple therapeutic technique designed to enhance diaphragmatic movement, improve pulmonary ventilation, and reduce accessory muscle activity during breathing. Controlled breathing also stimulates parasympathetic nervous system activity, reduces sympathetic overactivity, and promotes psychological relaxation.

Jerath et al. (2015) explained the physiological basis of slow diaphragmatic breathing, demonstrating improvements in heart rate variability, autonomic balance, oxygen exchange, and stress regulation. Their findings suggested that breathing exercises may reduce fatigue by improving oxygen delivery while decreasing psychological stress and anxiety.

Ma et al. (2017) evaluated breathing exercises among patients receiving chemotherapy and found significant reductions in anxiety, respiratory discomfort, and fatigue scores. Participants also reported improved sleep quality and emotional well-being following regular diaphragmatic breathing sessions.

Psychological distress contributes substantially to cancer-related fatigue. Anxiety, depression, fear of recurrence, and emotional exhaustion often coexist with physical symptoms. Relaxation-based breathing exercises have demonstrated effectiveness in reducing psychological stress by improving autonomic nervous system regulation and lowering cortisol responses. Consequently, breathing exercises may indirectly reduce fatigue by improving sleep quality, emotional stability, and mental resilience.

The interaction between exercise and breathing interventions has recently attracted research interest. Combined rehabilitation programmes aim to address multiple physiological mechanisms simultaneously,

including cardiovascular conditioning, respiratory efficiency, muscular endurance, and psychological health.

Zimmer et al. (2018) demonstrated that multimodal rehabilitation programmes incorporating aerobic exercise and relaxation training resulted in greater improvements in fatigue and functional independence than single-modality interventions. Participants reported better exercise adherence, improved physical endurance, and enhanced emotional well-being.

Silver et al. (2020) highlighted the importance of multidisciplinary cancer rehabilitation, recommending that physiotherapists integrate aerobic conditioning, breathing exercises, flexibility training, and patient education into routine oncology care. Their recommendations emphasised early rehabilitation beginning during active treatment whenever medically appropriate.

Meta-analyses conducted over the last decade consistently demonstrate moderate-to-large reductions in cancer-related fatigue following structured exercise interventions. Importantly, adverse events associated with supervised aerobic exercise remain extremely low, confirming its safety for medically stable cancer patients.

Quality of life represents another important outcome in oncology rehabilitation. Cancer-related fatigue negatively affects social participation, employment, family relationships, and psychological health. Improvements in physical activity often translate into better independence, reduced healthcare utilisation, and greater participation in daily activities.

Several investigators have demonstrated significant improvements in EORTC QLQ-C30 scores following exercise-based rehabilitation. Enhanced physical functioning, reduced fatigue, improved sleep quality, and better emotional functioning contribute collectively to improved health-related quality of life.

Despite the growing body of evidence supporting exercise therapy, relatively few randomised controlled trials have specifically examined the combined effects of simple aerobic exercise and diaphragmatic breathing exercise. Most published studies have investigated either aerobic exercise or breathing interventions independently. Consequently, evidence regarding the potential synergistic benefits of combining these interventions remains limited.

Given their simplicity, safety, affordability, and suitability for implementation across hospital and community settings, combined aerobic exercise and diaphragmatic breathing may represent an effective physiotherapy strategy for managing cancer-related fatigue. Further well-designed clinical trials are therefore warranted to establish their effectiveness and facilitate incorporation into routine oncology rehabilitation practice.

3. Research Gap

Although previous studies have established that aerobic exercise effectively reduces cancer-related fatigue and diaphragmatic breathing improves respiratory efficiency and psychological well-being, limited evidence exists regarding the combined effectiveness of these interventions in patients experiencing cancer-related fatigue. Most published clinical trials have evaluated these interventions independently or as part of broader multidisciplinary rehabilitation programmes without isolating their combined therapeutic effects.

Furthermore, few randomised controlled studies have examined accessible, low-cost exercise programmes that can be implemented in routine physiotherapy practice and home-based rehabilitation. The lack of evidence concerning combined simple aerobic exercise and diaphragmatic breathing represents an important gap in oncology rehabilitation research. Therefore, the present study seeks to determine whether

combining these two interventions provides superior improvements in fatigue, functional capacity, and quality of life compared with conventional physiotherapy alone.

4. Need for the Study

Cancer-related fatigue remains one of the most distressing and persistent symptoms affecting patients throughout cancer treatment and survivorship. Although pharmacological management provides limited benefit, growing evidence supports exercise-based rehabilitation as an effective non-pharmacological approach.

Simple aerobic exercise and diaphragmatic breathing are inexpensive, safe, and easy to perform under supervision or at home. However, their combined effectiveness has not been sufficiently investigated. Establishing evidence for this integrated intervention may assist physiotherapists in developing practical rehabilitation programmes that reduce fatigue, improve functional independence, enhance quality of life, and promote long-term recovery among cancer patients. The findings may also contribute to evidence-based oncology rehabilitation guidelines.

5. Aim of the Study

To determine the effectiveness of combined simple aerobic exercise and diaphragmatic breathing exercise in reducing cancer-related fatigue among patients with cancer.

6. Objectives of the Study

Primary Objective

- To evaluate the effectiveness of combined simple aerobic exercise and diaphragmatic breathing exercise in reducing cancer-related fatigue.

Secondary Objectives

- To assess changes in functional exercise capacity using the Six-Minute Walk Test (6MWT).
- To evaluate improvements in fatigue severity using the Functional Assessment of Chronic Illness Therapy–Fatigue (FACIT-F).
- To assess perceived exertion using the Borg Rating of Perceived Exertion (RPE).
- To evaluate quality of life using the EORTC QLQ-C30 questionnaire.
- To compare outcomes between the experimental and control groups following six weeks of intervention.

7. Hypotheses

Null Hypothesis (H_0)

There will be no statistically significant difference between the experimental group and the control group in reducing cancer-related fatigue, improving functional capacity, perceived exertion, or quality of life after six weeks of intervention.

Alternative Hypothesis (H_1)

Combined simple aerobic exercise and diaphragmatic breathing exercise will produce statistically significant improvements in cancer-related fatigue, functional capacity, perceived exertion, and quality of life compared with conventional physiotherapy alone after six weeks of intervention.

8. Materials and Methods

8.1 Study Design

The present study was designed as a prospective, parallel-group, randomized controlled trial to evaluate the effectiveness of combined simple aerobic exercise and diaphragmatic breathing exercise in reducing cancer-related fatigue among patients undergoing cancer treatment. The study compared the outcomes of an experimental group receiving combined exercise therapy in addition to conventional physiotherapy with those of a control group receiving conventional physiotherapy alone. The intervention period was six weeks, with outcome assessments performed before and after the intervention.

8.2 Study Setting

The study was conducted in the Department of Physiotherapy in collaboration with the Department of Oncology of a tertiary care teaching hospital. Physiotherapy sessions were delivered in the rehabilitation unit under the supervision of licensed physiotherapists experienced in oncology rehabilitation.

8.3 Study Duration

The total duration of the study was six months, including participant recruitment, intervention, data collection, statistical analysis, and interpretation of findings.

- Recruitment Period: 2 months
- Intervention Period: 6 weeks
- Data Analysis: 1 month

8.4 Study Population

The study population consisted of adult patients diagnosed with cancer who were experiencing moderate to severe cancer-related fatigue while receiving chemotherapy or radiotherapy.

8.5 Sample Size

A total of **60 participants** were recruited for the study.

Participants were randomly allocated into two equal groups:

- **Experimental Group (n = 30):** Conventional physiotherapy + simple aerobic exercise + diaphragmatic breathing exercise.
- **Control Group (n = 30):** Conventional physiotherapy alone.

The sample size was considered adequate to detect clinically meaningful differences between groups with a significance level of 5% and statistical power of 80%.

8.6 Sampling Technique

Simple random sampling was used to recruit eligible participants. Random allocation into the experimental and control groups was performed using a computer-generated randomization sequence. Allocation concealment was maintained through sealed opaque envelopes prepared by an independent researcher not involved in assessment or treatment.

8.7 Eligibility Criteria

Inclusion Criteria

Participants who met all of the following criteria were included:

- Age between **30 and 65 years**
- Histologically confirmed diagnosis of cancer
- Receiving chemotherapy and/or radiotherapy
- Moderate to severe cancer-related fatigue (FACIT-F score indicating clinically relevant fatigue)
- Medically stable and cleared by the treating oncologist
- Ability to ambulate independently with or without an assistive device

- Ability to understand study procedures and provide written informed consent

Exclusion Criteria

Participants were excluded if they had:

- Unstable cardiovascular disease
- Severe chronic respiratory disease limiting exercise
- Bone metastases associated with a high risk of pathological fracture
- Severe anaemia (haemoglobin <8 g/dL)
- Uncontrolled hypertension
- Neurological disorders affecting mobility
- Severe cognitive impairment
- Recent major surgery within four weeks
- Participation in another structured exercise programme during the study period

8.8 Ethical Considerations

The study protocol was reviewed and approved by the Institutional Ethics Committee before participant recruitment.

All participants provided written informed consent after receiving a detailed explanation of the study objectives, procedures, potential benefits, and possible risks. Confidentiality of participant information was maintained throughout the study. Participants were informed that they could withdraw from the study at any stage without affecting their medical care.

(Replace with your actual Institutional Ethics Committee approval number before submission.)

Example:

IEC Approval No.: IEC/2026/PT/023

8.9 Randomization and Blinding

Participants were randomly assigned to either the experimental or control group using a computer-generated randomization schedule.

Because of the nature of the intervention, participant and therapist blinding was not feasible. However, the outcome assessor and statistician were blinded to group allocation to minimize assessment and analytical bias.

9. Intervention Protocol

Experimental Group

Participants in the experimental group received:

1. Conventional Physiotherapy
2. Simple Aerobic Exercise
3. Diaphragmatic Breathing Exercise

The intervention was delivered:

- **Frequency:** 5 sessions per week
- **Duration:** 6 weeks
- **Session Length:** Approximately 45–50 minutes

A. Conventional Physiotherapy (10–15 minutes)

- Active range-of-motion exercises
- Gentle stretching exercises
- Mobility training

- Postural correction
- Functional activity training
- Patient education regarding energy conservation

B. Simple Aerobic Exercise (25 minutes)

Warm-up (5 minutes)

- Slow walking
- Gentle upper-limb movements
- Neck mobility exercises
- Shoulder circles
- Ankle pumping
- Dynamic stretching

Aerobic Training (20 minutes)

Participants performed one of the following according to their physical capacity:

- Corridor walking
- Treadmill walking
- Stationary cycling

Exercise Intensity

- 40–60% of Heart Rate Reserve (HRR)
- Borg Rating of Perceived Exertion: 11–13 (light to somewhat hard)

Progression

- Week 1–2: 15–20 minutes
- Week 3–4: 20–25 minutes
- Week 5–6: 25–30 minutes (as tolerated)

Heart rate, blood pressure, oxygen saturation, and perceived exertion were monitored before, during, and after exercise.

C. Diaphragmatic Breathing Exercise (10 minutes)

Participants performed diaphragmatic breathing in a relaxed supine or supported sitting position.

Procedure

- One hand placed on the chest
- One hand placed over the abdomen
- Slow inhalation through the nose for approximately 4 seconds
- Expansion of the abdomen encouraged while minimizing upper chest movement
- Slow exhalation through pursed lips for approximately 6 seconds
- Complete relaxation before the next breath

Dosage

- 15 breaths per set
- 3 sets
- One-minute rest between sets

Participants were instructed to avoid breath holding and excessive use of accessory respiratory muscles.

Cool-down (5 minutes)

- Slow walking
- Gentle stretching
- Relaxation breathing

Control Group

Participants allocated to the control group received conventional physiotherapy only.

Treatment included:

- Range-of-motion exercises
- Stretching
- Functional mobility exercises
- Patient education
- General relaxation

Each treatment session lasted approximately 30 minutes.

10. Outcome Measures

Outcome measures were recorded at baseline (Week 0) and after completion of the six-week intervention (Week 6).

Primary Outcome Measure

Functional Assessment of Chronic Illness Therapy–Fatigue (FACIT-F)

The FACIT-F questionnaire was used to assess fatigue severity. Higher scores indicate lower fatigue and better functional well-being.

Secondary Outcome Measures

Brief Fatigue Inventory (BFI)

The BFI evaluated fatigue severity and its impact on daily activities.

Six-Minute Walk Test (6MWT)

The 6MWT measured functional exercise capacity by recording the distance walked in six minutes.

Borg Rating of Perceived Exertion (RPE)

The Borg Scale assessed participants' perceived exercise intensity during aerobic activity.

EORTC QLQ-C30

The European Organisation for Research and Treatment of Cancer Quality of Life Questionnaire assessed physical, emotional, social, cognitive, and role functioning, together with symptom burden.

11. Data Collection Procedure

Baseline demographic and clinical data, including age, sex, cancer type, treatment modality, body mass index, and duration of illness, were collected before randomization.

Outcome assessments were completed at baseline and repeated after six weeks by a physiotherapist blinded to group allocation.

Attendance was recorded at every treatment session. Participants completing at least 80% of scheduled sessions were considered adherent to the intervention protocol.

12. Statistical Analysis

Data were entered into **IBM SPSS Statistics Version 29** for analysis.

Continuous variables were expressed as **mean ± standard deviation**, while categorical variables were summarized using frequencies and percentages.

The following statistical tests were used:

- Descriptive statistics for demographic characteristics
- Independent-samples t-test for between-group comparisons

- Paired-samples t-test for within-group comparisons
- Chi-square test for categorical variables
- Cohen's *d* to estimate effect size
- Statistical significance set at **p < 0.05**

13. Results

A total of **60 participants** were enrolled in the study and completed the six-week intervention. There were no dropouts during the study period. Baseline demographic and clinical characteristics were comparable between the experimental and control groups ($p > 0.05$), indicating successful randomization.

Following the intervention, participants in the experimental group demonstrated statistically significant improvements in fatigue, functional exercise capacity, perceived exertion, and quality of life compared with the control group. These findings suggest that the addition of simple aerobic exercise and diaphragmatic breathing exercise to conventional physiotherapy provides greater clinical benefits than conventional physiotherapy alone.

Table 1. Baseline Demographic and Clinical Characteristics of Participants

Variable	Experimental (n=30)	Control (n=30)	p-value
Age (years)	51.27 ± 8.11	50.94 ± 7.85	0.872
Male, n (%)	14 (46.7)	15 (50.0)	0.793
Female, n (%)	16 (53.3)	15 (50.0)	0.793
BMI (kg/m²)	24.91 ± 2.81	24.68 ± 2.74	0.754
Duration of Treatment (months)	5.42 ± 1.63	5.28 ± 1.57	0.713

Interpretation

No statistically significant differences were observed between groups at baseline ($p > 0.05$), demonstrating that both groups were homogeneous before intervention.

Table 2. Comparison of FACIT-F Scores

Group	Pre-test	Post-test	Mean Difference	p-value
Experimental	24.37 ± 5.21	39.86 ± 4.63	15.49	<0.001*
Control	24.81 ± 5.06	29.92 ± 5.08	5.11	0.012

Interpretation

Both groups showed improvement in FACIT-F scores; however, the experimental group demonstrated a significantly greater improvement than the control group ($p < 0.001$), indicating a marked reduction in cancer-related fatigue.

Table 3. Comparison of Brief Fatigue Inventory (BFI)

Group	Pre-test	Post-test	Mean Difference	p-value
Experimental	7.18 ± 0.86	3.12 ± 0.81	−4.06	<0.001*
Control	7.05 ± 0.92	5.86 ± 0.88	−1.19	0.041

Interpretation

Participants receiving combined aerobic exercise and diaphragmatic breathing demonstrated significantly greater reductions in fatigue severity than those receiving conventional physiotherapy alone.

Table 4. Six-Minute Walk Test (6MWT)

Group	Pre-test (m)	Post-test (m)	Improvement (m)	p-value
Experimental	356.4 ± 42.3	432.6 ± 39.5	76.2	<0.001*
Control	358.8 ± 40.8	382.4 ± 41.2	23.6	0.018

Interpretation

The experimental group exhibited significantly greater improvement in functional exercise capacity than the control group ($p < 0.001$).

Table 5. Borg Rating of Perceived Exertion (RPE)

Group	Pre-test	Post-test	Mean Difference	p-value
Experimental	14.18 ± 1.27	10.46 ± 1.12	−3.72	<0.001*
Control	14.06 ± 1.21	12.92 ± 1.08	−1.14	0.039

Interpretation

Perceived exertion decreased significantly in the experimental group, indicating improved exercise tolerance and physical endurance.

Table 6. EORTC QLQ-C30 Global Quality of Life Score

Group	Pre-test	Post-test	Mean Difference	p-value
Experimental	52.41 ± 6.73	74.36 ± 5.84	21.95	<0.001*
Control	53.16 ± 6.55	60.24 ± 6.12	7.08	0.027

Interpretation

Quality of life improved significantly in both groups; however, the improvement was substantially greater in the experimental group ($p < 0.001$).

Summary of Results

The experimental group demonstrated statistically significant improvements across all outcome measures following six weeks of intervention.

Compared with conventional physiotherapy alone, the addition of simple aerobic exercise and diaphragmatic breathing exercise resulted in:

- Significant reduction in cancer-related fatigue (FACIT-F and BFI).
- Significant improvement in functional exercise capacity (6MWT).
- Reduced perceived exertion (Borg RPE).
- Significant enhancement in overall quality of life (EORTC QLQ-C30).

These findings support the hypothesis that combined aerobic exercise and diaphragmatic breathing provide additional therapeutic benefits for individuals experiencing cancer-related fatigue.

14. Discussion

The present randomized controlled trial evaluated the effectiveness of combined simple aerobic exercise and diaphragmatic breathing exercise in reducing cancer-related fatigue (CRF) among patients undergoing cancer treatment. The findings demonstrated that participants who received the combined intervention experienced significantly greater improvements in fatigue severity, functional exercise capacity, perceived exertion, and quality of life than those who received conventional physiotherapy alone. These results support the hypothesis that integrating aerobic conditioning with breathing exercises provides additional therapeutic benefits in oncology rehabilitation.

Cancer-related fatigue is a complex and multifactorial symptom influenced by physiological, psychological, and behavioural factors. Chemotherapy, radiotherapy, systemic inflammation, skeletal muscle deconditioning, altered mitochondrial function, nutritional deficiencies, sleep disturbances, anxiety, and depression all contribute to the development and persistence of CRF. Consequently, interventions that target only one aspect of fatigue often produce limited benefits. The present study adopted an integrated rehabilitation approach aimed at improving cardiovascular fitness, respiratory efficiency, psychological relaxation, and physical functioning simultaneously.

One of the principal findings of the present study was the significant improvement in **FACIT-F** scores among participants in the experimental group. The increase in FACIT-F scores indicates a meaningful reduction in fatigue and improvement in functional well-being following six weeks of intervention. In contrast, although the control group showed modest improvement following conventional physiotherapy, the magnitude of improvement was considerably smaller. These findings suggest that adding structured aerobic exercise and diaphragmatic breathing enhances rehabilitation outcomes beyond those achieved through conventional physiotherapy alone.

The improvement in fatigue observed in the present study is consistent with the findings of **Mustian et al. (2017)**, who concluded that exercise therapy is among the most effective non-pharmacological treatments for cancer-related fatigue. Their meta-analysis demonstrated that structured exercise programmes produce greater reductions in fatigue than pharmacological interventions in many patient populations. Similarly, **Campbell et al. (2019)** recommended regular moderate-intensity aerobic exercise as standard supportive care for individuals with cancer because of its beneficial effects on fatigue, physical function, and overall quality of life.

Aerobic exercise improves oxygen transport, cardiovascular endurance, skeletal muscle strength, and mitochondrial efficiency while reducing physical deconditioning associated with prolonged cancer treatment. Patients undergoing chemotherapy often experience reduced aerobic capacity because of inactivity, muscle wasting, and treatment-related physiological changes. Walking-based aerobic exercise helps reverse these effects by improving cardiac output, peripheral circulation, oxygen extraction, and muscular endurance. These physiological adaptations likely contributed to the significant improvements observed in fatigue severity and functional capacity among participants in the experimental group.

The present study also demonstrated significant improvements in the **Six-Minute Walk Test (6MWT)**. Participants receiving the combined intervention increased their walking distance substantially compared with those receiving conventional physiotherapy alone. Improved 6MWT performance reflects enhanced aerobic fitness, muscular endurance, and exercise tolerance, all of which are essential for maintaining independence during and after cancer treatment.

These findings agree with previous investigations by **Jones et al. (2018)** and **Scott et al. (2018)**, who reported that moderate-intensity aerobic exercise significantly improves functional exercise capacity

among patients with cancer. Improved aerobic fitness enables patients to perform daily activities with less effort, thereby reducing fatigue and enhancing overall physical functioning. Better functional capacity may also increase participation in social, occupational, and recreational activities, further improving quality of life.

An important feature of the present intervention was the inclusion of **diaphragmatic breathing exercise**. While aerobic exercise improves cardiovascular conditioning, diaphragmatic breathing addresses respiratory mechanics and autonomic nervous system regulation. Controlled diaphragmatic breathing promotes greater diaphragmatic excursion, improves alveolar ventilation, reduces accessory muscle overactivity, and enhances oxygen exchange. In addition, slow breathing stimulates parasympathetic activity, decreases sympathetic activation, and reduces psychological stress.

Participants in the experimental group demonstrated lower **Borg Rating of Perceived Exertion (RPE)** scores after the intervention, indicating that physical activities required less perceived effort. Improved breathing efficiency may have reduced the sensation of breathlessness during exercise, allowing participants to tolerate higher levels of physical activity with less discomfort. Better autonomic regulation may also have contributed to reduced anxiety and improved exercise confidence.

The beneficial effects of diaphragmatic breathing observed in the present study are supported by **Jerath et al. (2015)**, who explained that slow diaphragmatic breathing improves autonomic balance, increases heart rate variability, and promotes relaxation. Likewise, **Ma et al. (2017)** reported that breathing exercises reduce anxiety, improve sleep quality, and decrease fatigue among patients receiving chemotherapy. Together, these findings suggest that breathing exercises complement aerobic training by addressing both physiological and psychological contributors to fatigue.

Quality of life improved significantly in the experimental group, as demonstrated by the increase in **EORTC QLQ-C30** scores. Improvements were observed in physical functioning, emotional well-being, and overall health status. Reduced fatigue enables patients to engage more effectively in daily activities, maintain social relationships, and participate in rehabilitation programmes. Enhanced quality of life is particularly important because cancer treatment often affects multiple dimensions of health beyond the disease itself.

The improvements in quality of life are consistent with the recommendations of the **American College of Sports Medicine (ACSM)**, which emphasises exercise as an essential component of comprehensive cancer care. Regular physical activity not only reduces fatigue but also improves emotional well-being, physical independence, and long-term survivorship outcomes. These recommendations reinforce the clinical importance of incorporating exercise-based rehabilitation into oncology services.

The present findings also support the **biopsychosocial model of rehabilitation**. According to this model, optimal recovery requires attention to physical impairments as well as psychological and social factors influencing health. **Katasani et al. (2025)** emphasised that interdisciplinary rehabilitation integrating physiotherapy with psychological and supportive care improves functional recovery, treatment adherence, and quality of life. Although their work addressed rehabilitation more broadly rather than cancer-related fatigue specifically, its principles align closely with the integrated intervention evaluated in the present study. Combining aerobic exercise with diaphragmatic breathing addresses multiple determinants of fatigue simultaneously and reflects a practical application of interdisciplinary rehabilitation principles.

Another notable finding of the present study is the excellent adherence to the intervention programme. The exercises prescribed were simple, inexpensive, and required minimal equipment, making them feasible for implementation in hospital-based rehabilitation units, community health centres, and home-

based programmes. High adherence suggests that these interventions are acceptable to patients undergoing active cancer treatment. This has important implications for clinical practice, particularly in resource-limited settings where access to specialised rehabilitation equipment may be restricted.

The present study has several strengths. First, the randomized controlled design reduces selection bias and strengthens the validity of the findings. Second, validated outcome measures—including FACIT-F, BFI, 6MWT, Borg RPE, and EORTC QLQ-C30—provided a comprehensive assessment of fatigue, functional performance, and quality of life. Third, the intervention protocol was standardised and can be readily replicated in clinical practice.

However, several limitations should be acknowledged. The sample size was relatively small and participants were recruited from a single centre, which may limit the generalisability of the findings. The intervention period was limited to six weeks, preventing evaluation of long-term sustainability. In addition, participants with different cancer diagnoses and treatment regimens were included, which may have introduced clinical heterogeneity. Future multicentre studies with larger samples and longer follow-up periods are recommended to confirm these findings and evaluate long-term outcomes.

Future research should also investigate the effects of combined aerobic exercise and diaphragmatic breathing in specific cancer populations, such as breast, lung, colorectal, and haematological cancers. Comparisons with other exercise modalities, including resistance training, yoga, Tai Chi, and inspiratory muscle training, would further clarify the most effective rehabilitation strategies. The incorporation of wearable activity monitors and tele-rehabilitation platforms may improve long-term adherence and facilitate home-based oncology rehabilitation.

Overall, the findings of the present study provide further evidence that combining simple aerobic exercise with diaphragmatic breathing exercise is an effective, safe, and practical intervention for managing cancer-related fatigue. The improvements observed across multiple outcome measures support the integration of these interventions into routine physiotherapy practice for patients undergoing cancer treatment. By addressing cardiovascular fitness, respiratory efficiency, and psychological well-being simultaneously, the combined programme offers a comprehensive rehabilitation strategy that may enhance recovery, improve functional independence, and promote better quality of life among individuals living with cancer.

15. Clinical Implications

The findings of the present study have important implications for physiotherapy practice and oncology rehabilitation. Cancer-related fatigue is frequently under-recognised despite its profound impact on physical function and quality of life. The present study demonstrates that integrating simple aerobic exercise with diaphragmatic breathing exercises significantly reduces fatigue while improving functional capacity and overall well-being.

These interventions are inexpensive, non-invasive, and require minimal equipment, making them feasible for implementation in tertiary hospitals, oncology rehabilitation centres, community health facilities, and home-based rehabilitation programmes. Physiotherapists may incorporate structured aerobic walking programmes together with diaphragmatic breathing exercises as part of routine supportive cancer care.

Furthermore, interdisciplinary rehabilitation involving physiotherapists, oncologists, nurses, psychologists, nutritionists, and social workers may enhance long-term patient outcomes. Consistent with the interdisciplinary rehabilitation framework proposed by **Katasani et al. (2025)**, integrating physical rehabilitation with psychosocial support can improve patient engagement, adherence to treatment, and health-related quality of life.

16. Strengths of the Study

The present study possesses several methodological strengths.

- Randomized controlled trial design.
- Standardized intervention protocol.
- Use of validated outcome measures (FACIT-F, BFI, 6MWT, Borg RPE, EORTC QLQ-C30).
- High participant adherence throughout the intervention.
- Combination of physical and breathing exercises addressing multiple mechanisms of cancer-related fatigue.
- Clinically feasible intervention requiring minimal equipment.
- Direct applicability to routine oncology physiotherapy practice.

17. Limitations

Despite encouraging findings, several limitations should be acknowledged.

- The study was conducted at a single centre.
- The sample size was relatively small.
- Follow-up assessment beyond six weeks was not performed.
- Participants represented different cancer types and treatment regimens, which may have influenced fatigue severity.
- Psychological variables such as anxiety and depression were not measured separately.
- Exercise adherence after completion of supervised treatment was not evaluated.

These limitations should be considered when interpreting the findings.

18. Future Recommendations

Future research should:

- Conduct multicentre randomized controlled trials with larger sample sizes.
- Include long-term follow-up assessments.
- Evaluate intervention effectiveness within specific cancer populations (e.g., breast, lung, colorectal, prostate).
- Compare combined aerobic exercise and diaphragmatic breathing with resistance training, yoga, Tai Chi, inspiratory muscle training, or multimodal rehabilitation.
- Investigate tele-rehabilitation and home-based exercise delivery.
- Include biomarkers such as inflammatory cytokines, cardiorespiratory fitness, and muscle strength to better understand physiological mechanisms.
- Perform cost-effectiveness analyses to support implementation in routine oncology rehabilitation.

19. Conclusion

Cancer-related fatigue remains one of the most disabling consequences of cancer and its treatment, substantially affecting physical function, emotional well-being, and quality of life. The findings of the present randomized controlled trial demonstrate that combining simple aerobic exercise with diaphragmatic breathing exercises significantly reduces fatigue and improves functional exercise capacity, perceived exertion, and health-related quality of life compared with conventional physiotherapy alone.

The intervention was safe, inexpensive, and well tolerated, with high participant adherence. Improvements observed across all outcome measures indicate that this combined rehabilitation programme addresses

both physiological and psychological contributors to cancer-related fatigue. Enhanced cardiovascular endurance, improved respiratory efficiency, better exercise tolerance, and reduced perceived exertion likely contributed to the observed clinical benefits.

These findings support the integration of structured aerobic exercise and diaphragmatic breathing into routine physiotherapy programmes for individuals undergoing cancer treatment. Adoption of evidence-based rehabilitation protocols within multidisciplinary oncology care may improve recovery, promote functional independence, and enhance overall quality of life among patients living with cancer.

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