British Journal of Hospital Medicine

Br. J. Hosp. Med. (Lond) **2026**; 87(9): 50603
https://doi.org/10.31083/BJHM50603

Article

The Effect of Electromyographic Biofeedback Relaxation Training on Pain Catastrophizing and Fatigue Levels in Lung Cancer Patients Undergoing Combined Chemoradiotherapy

Xiaoling Fu[1], Huiwei Wang[2], Xiaoni Lin[3], Liying Chen[3], Jingjing Hu[4], Yeling Wang[5], Fang Yin[6], Weiying Wu[3,*]

[1]Emergency Department, Haikou Affiliated Hospital of Central South University Xiangya School of Medicine, 570208 Haikou, Hainan, China
[2]Department of Oncology, Haikou Affiliated Hospital of Central South University Xiangya School of Medicine, 570208 Haikou, Hainan, China
[3]Department of Radiotherapy, Haikou Affiliated Hospital of Central South University Xiangya School of Medicine, 570208 Haikou, Hainan, China
[4]Department of Respiratory, Hainan Provincial People's Hospital, 570311 Haikou, Hainan, China
[5]Department of Radiotherapy, The First Affiliated Hospital of Hainan Medical University, 570102 Haikou, Hainan, China
[6]Department of Oncology, The Second Affiliated Hospital of Hainan Medical University, 570311 Haikou, Hainan, China
*Correspondence: wwy888559@163.com (Weiying Wu)
Academic Editor: John Alcolado
Submitted: 2 February 2026 Revised: 29 April 2026 Accepted: 16 June 2026 Published: 15 September 2026

Abstract

Aims/Background: Lung cancer patients undergoing combined chemoradiotherapy often experience pain, fatigue, sleep disturbances, and decreased quality of life. Among these, pain catastrophizing, as a negative cognitive pattern, can exacerbate symptom experience. Similarly, fatigue and sleep disturbances are also influenced by psychological and cognitive factors, yet conventional supportive care provides limited intervention at the psychological and cognitive levels. This study aims to investigate the impact of electromyographic biofeedback relaxation training on pain catastrophizing and fatigue levels in lung cancer patients undergoing combined chemoradiotherapy. **Methods:** This study employed a single-center, retrospective cohort design. Through a review of medical records from March 2020 to March 2022, patients who had received structured electromyographic biofeedback relaxation training undergoing chemoradiotherapy were assigned to an observation group ($n = 78$). Patients without such records, receiving only routine supportive care, were classified as a control group ($n = 109$). The training consisted of six sessions over two weeks. Outcomes, including pain catastrophizing (Pain Catastrophizing Scale), pain intensity (Visual Analogue Scale), sleep quality (European Organisation for Research and Treatment of Cancer), and quality of life (Functional Assessment of Chronic Illness Therapy-Fatigue), were assessed before and after the intervention period. **Results:** After the intervention, the pain catastrophism scores, pain intensity scores, and sleep disturbance scores of the observation group were significantly lower than those of the control group, while the fatigue score was significantly higher than that of the control group (all $p < 0.05$). Furthermore, the observation group also showed significantly better scores and total scores on multiple dimensions of quality of life (including physical well-being, social/family well-being, emotional health, functional well-being, and fatigue subscales) than the control group ($p < 0.05$). **Conclusions:** Supplementing routine combined chemoradiotherapy management with electromyographic biofeedback relaxation training was associated with lower levels of pain catastrophizing and fatigue, improved sleep quality, and enhanced overall quality of life in lung cancer patients. This intervention may represent a safe and feasible non-pharmacological support strategy for symptom management in lung cancer patients undergoing combined chemoradiotherapy.

Keywords: lung neoplasms; chemoradiotherapy; biofeedback, psychology; catastrophizing

1. Introduction

Lung cancer represents a malignancy characterized by an extremely high disease burden globally and in China, and poses a persistent public health challenge with sustainably high incidence and mortality rates [1,2,3]. Chemotherapy and radiotherapy remain the most commonly employed treatment modalities for lung cancer, accounting for the largest proportion of patients treated in clinical practice [4,5,6]. For patients with intermediate and advanced lung cancer, chemotherapy or radiotherapy alone is often difficult to achieve both local control and systemic disease management. Therefore, their combined use provides an effective treatment strategy [7]. Whether it is concurrent chemoradiotherapy or sequential chemoradiotherapy, the core goal is to improve the tumor control rate, delay disease progression, and improve patient survival outcomes through the synergistic effect of local and systemic treatment [8]. Overall, chemoradiotherapy has irreplaceable clinical value in lung cancer treatment [9]. However, it is important to note that while chemotherapy, radiotherapy, and other anti-tumor treatment regimens exert therapeutic effects, they are also inevitably accompanied by a series of treatment-related adverse reactions [10]. Due to the high intensity of treatment and the relatively long treatment cycle, lung cancer patients receiving chemoradiotherapy often experience multi-system symptoms, among which pain catas-

trophizing and fatigue are the most common and cause a high degree of distress to patients [11,12,13]. Persistent or recurring pain not only affects patients' physical comfort, but may also aggravate patients' fear and helplessness regarding treatment, and induce or exacerbate negative emotional reactions such as anxiety and depression [14]. At the same time, cancer-related fatigue, as a subjective symptom characterized by its persistence and difficulty in being relieved by rest, has a high incidence in lung cancer patients undergoing combined chemoradiotherapy, and it often becomes more severe throughout the course of treatment [15]. Fatigue can significantly limit patients' physical activity and daily living functions, reduce their social participation and overall quality of life, and has emerged as a key factor affecting treatment tolerance and overall treatment experience [16].

Recent studies have gradually shown that the experience of pain catastrophizing and fatigue is deeply influenced by psychological and cognitive factors, among which pain catastrophizing (i.e., excessive fear, exaggeration, and helplessness about pain) serves as a key mediating factor [17,18]. Patients with higher levels of pain catastrophizing are often more sensitive to pain stimuli and more likely to experience negative emotions, thereby fostering a vicious cycle in which pain, fatigue, and emotional response mutually reinforce one another [19]. In the highly stressful treatment context of chemotherapy, radiotherapy, and combined treatment, pain catastrophizing may play an important mediating role in the aggravation of symptom burden and changes in psychological state. At present, for lung cancer patients undergoing combined chemoradiotherapy, the clinical intervention employed for addressing pain catastrophizing and fatigue is mostly grounded in medications and routine supportive guidance [20]. Although drug analgesia and symptomatic treatment can alleviate discomfort symptoms to some extent, long-term use may lead to problems such as increased tolerance and increased risk of adverse reactions, and their regulatory effect on patients' psychological and cognitive level is relatively limited [21]. Therefore, exploring non-pharmacological intervention strategies that are safe, feasible, and capable of simultaneously addressing both physiological and psychological aspects has become an important research direction in the fields of supportive care and symptom management.

Electromyographic biofeedback relaxation training is a behavioral intervention technique based on the principle of physiological signal feedback. It transforms objective physiological indicators such as muscle tension into intuitive visual or auditory signals, helping individuals to perceive changes in their own physiological state and actively regulate themselves, thereby achieving physical and mental relaxation and symptom relief [22]. A previous study has shown that electromyographic biofeedback has certain effects on chronic pain, anxiety, and functional fatigue. Its potential mechanism may be related to reducing muscle tension, improving the balance of autonomic nervous system function, and enhancing individual self-regulatory ability [23]. However, research on the effects of electromyographic biofeedback relaxation training on pain catastrophizing and fatigue in lung cancer patients receiving combined chemoradiotherapy is still relatively limited.

In this study, lung cancer patients undergoing combined chemoradiotherapy were recruited as research subjects. In addition to routine clinical supportive management, electromyographic biofeedback relaxation training was employed, and the impact of this intervention on patients' pain catastrophizing and fatigue levels was examined. Through a comprehensive analysis from both symptom experience and psychological cognition perspectives, the potential value of this intervention model in improving patients' subjective symptom burden and overall treatment experience was evaluated. The study aims to provide a more systematic and individualized intervention approach for symptom management in lung cancer patients undergoing combined chemoradiotherapy, and to provide a theoretical basis and practical reference for the application of non-pharmacological, supportive care strategies in cancer patients.

2 Methods

2.1 Research Design and Participants

This retrospective cohort study consecutively enrolled lung cancer patients who received combined chemoradiotherapy (including both concurrent and sequential regimens) at Haikou Affiliated Hospital of Central South University Xiangya School of Medicine between March 2020 and March 2022. Inclusion criteria were as follows: (1) Patients with a confirmed diagnosis of lung cancer by pathological or cytological examination; (2) patients receiving combined chemoradiotherapy undergoing treatment; (3) patients who completed at least one full treatment cycle (duration $\geq$3 weeks); (4) patients aged $\geq$18 years; (5) patients with clear consciousness demonstrated normal comprehension and communication abilities, and had completed relevant scale assessments; (6) patients with complete clinical data and medical records. Exclusion criteria included: (1) Patients with comorbid severe mental disorders, cognitive impairment, or impaired consciousness; (2) patients with comorbid malignancies or other serious systemic diseases; (3) patients who failed to complete the planned clinical intervention due to rapid disease progression, treatment interruption, or transfer to another hospital; (4) patients who had previously received systematic biofeedback training or other professional psychological and behavioral interventions; and (5) patients with incomplete clinical data or follow-up assessment records, which rendered effective analysis impossible.

A total of 187 patients were ultimately included. Group assignment in this retrospective study was based on objective records from the electronic medical record sys-

Table 1. Baseline characteristics of participants.

Variables	Control group (n = 109)	Observation group (n = 78)	Statistic	p
Age (years)	56.10 ± 12.68	55.54 ± 12.41	t = 0.302	0.763
BMI (kg/m^2)	24.39 ± 2.18	24.95 ± 2.04	t = –1.784	0.076
Sex, n (%)			χ^2 = 0.020	0.889
Male	64 (58.72)	45 (57.69)		
Female	45 (41.28)	33 (42.31)		
Clinical stage, n (%)			χ^2 = 0.062	0.803
IV	14 (12.84)	11 (14.10)		
III	95 (87.16)	67 (85.90)		
Tumor pathological type, n (%)			χ^2 = 3.798	0.150
Squamous cell carcinoma	25 (22.94)	26 (33.33)		
Adenocarcinoma	66 (60.55)	45 (57.69)		
Others	18 (16.51)	7 (8.97)		
Comorbidities, n (%)			χ^2 = 2.363	0.501
Hypertension	63 (57.80)	45 (57.69)		
Other lung diseases	17 (15.60)	8 (10.26)		
Diabetes	22 (20.18)	16 (20.51)		
None	7 (6.42)	9 (11.54)		
Region of residence, n (%)			χ^2 = 0.156	0.693
Urban areas	77 (70.64)	53 (67.95)		
Rural areas	32 (29.36)	25 (32.05)		
Smoking status, n (%)			χ^2 = 0.531	0.466
No	39 (35.78)	32 (41.03)		
Yes	70 (64.22)	46 (58.97)		
Analgesic drug use, n (%)			χ^2 = 0.588	0.443
No	36 (33.03)	30 (38.46)		
Yes	73 (66.97)	48 (61.54)		
Prior treatment history, n (%)			χ^2 = 2.123	0.547
Radiotherapy	28 (25.69)	25 (32.05)		
Chemotherapy	40 (36.70)	21 (26.92)		
Immunotherapy	8 (7.34)	6 (7.69)		
Surgery	33 (30.28)	26 (33.33)		

tem. Patients with clear documentation in their rehabilitation treatment log of having completed six structured electromyographic biofeedback relaxation training sessions over two weeks during chemoradiotherapy were assigned to the observation group. Patients without any records of biofeedback or similar structured psychophysical interventions during the same treatment period, who received only routine supportive care for cancer, were assigned to the control group. Given the retrospective nature of this study, patients were not randomized to the observation or control groups. Group assignment was determined by the historical treatment records (presence or absence of biofeedback training). A comprehensive set of baseline characteristics was collected and compared (Table 1). The equipment used in this study is the Nanjing Weisi Bio-Stimulator & Feedback Apparatus S4 30 (Nanjing Weisi Medical Technology Co., Ltd., VISHEE, Nanjing, China).

2.2 Intervention Methods

Chemoradiotherapy was administered according to standard oncology protocols. Group assignment was based on the clinical support pathways documented in their medical records. Patients in the control group received the institution's standard supportive care during chemoradiotherapy. This standard care did not include any protocol-driven non-pharmacological psychological or behavioral interventions and comprised: (1) routine clinical monitoring and symptomatic follow-up according to departmental oncology practice; (2) pharmacological management of treatment-related adverse reactions (e.g., nausea, vomiting) in accordance with the Chinese Anti-Cancer Association (CACA) guidelines [24]; and (3) general guidance on activity and rest for fatigue management. These measures constituted the baseline supportive care provided to all patients in the study.

In addition to receiving the above-mentioned standard oncology treatments and supportive care, patients in the observation group received an additional structured elec-

tromyographic biofeedback relaxation training course. This intervention was conducted in the hospital's rehabilitation room under standardized environmental conditions, including a quiet setting, soft lighting, and a suitable ambient temperature to facilitate patient relaxation. The training was led by specially trained physicians. The therapist first explained the training principles and goals to the patients and assisted them in adopting a comfortable supine position. In practice, a nonspecific feedback mode was used, with surface electrodes placed on the patient's frontal muscle area to measure the overall levels of physical and mental tension. At the start of treatment, patients were briefed on the standardized relaxation instructions under the therapist's guidance, learned basic diaphragmatic breathing techniques, and attempted to perceive their baseline electromyographic activity level at rest. Formal biofeedback training included two stages: sensory establishment and self-regulation. Under the professional guidance of the therapist, patients learned to observe the real-time changes in their electromyographic activity on the display screen and attempted to reduce electromyographic signal level through subjective relaxation intentions. Once patients had established a basic connection between muscle tension and visual/auditory feedback, the training was progressively advanced. During training, therapists encouraged patients to actively regulate their electromyographic levels by applying the relaxation techniques they had learned while imagining scenarios that elicited anxiety or discomfort, thereby facilitating the transfer of these skills to the management of treatment-related stress. Each training session lasted approximately 30–45 minutes, with a frequency of 3 times per week. The entire course lasted 2 weeks, totaling 6 sessions. Throughout the process, therapists provided personalized guidance and positive encouragement based on real-time patient feedback and initiated brief discussions with patients after each training session to address any difficulties encountered in applying the techniques, thus reinforcing the learning outcomes. All training attendance, equipment parameters, and therapist observation notes are meticulously documented in the rehabilitation treatment record sheet and archived in the medical record system. To ensure the validity of the retrospective data, this study only included patients whose medical records explicitly state that they completed the entire cycle of standardized training within two weeks in the observation group for analysis.

2.3 Baseline Data Collection

The pre-intervention assessment was conducted at the initiation of chemoradiotherapy. The post-intervention assessment was conducted after the two-week intervention period, which coincided with the end of the first cycle of chemoradiotherapy for most patients. All assessments were performed as part of routine clinical care and documented in the electronic medical record system.

At baseline, the following demographic and clinical characteristics were collected to ensure comparability between groups: age, sex, body mass index (BMI), pathological type of tumor, clinical stage, comorbidities, place of residence, smoking status, analgesic use, and past treatment history. The clinical stage of patients in this study was assessed and recorded according to the American Joint Committee on Cancer (AJCC) Lung Cancer Staging Criteria 8 [25]. Inter-group comparisons of the collected data were performed using appropriately chosen statistical tests depending on whether they are continuous or categorical. Data from the Pain Catastrophizing Scale (PCS), Visual Analogue Scale (VAS), European Organisation for Research and Treatment of Cancer (EORTC) sleep subscale, and Functional Assessment of Chronic Illness Therapy-Fatigue (FACIT-F) questionnaire were derived from routine clinical assessments for lung cancer patients undergoing chemoradiotherapy at our institution.

2.4 Assessment Indicators for Pain Catastrophizing

The degree of pain catastrophizing in patients was measured using the Pain Catastrophizing Scale (PCS). This scale, developed by Sullivan et al. in 1995 [26], contains 13 items, each with a 5-point Likert score (0 = "never" to 4 = "always"), and a total score range of 0 to 52. The Chinese version of the scale has been validated in the Chinese population, including patients with chronic pain and cancer, showing good reliability (Cronbach's $\alpha > 0.90$) and validity [27]. Higher scores indicate greater fear of pain and more pronounced catastrophizing thoughts. This study compared pre- and post-intervention assessments to determine the effect of clinical intervention on improving pain catastrophizing.

2.5 Assessment of Sleep Disturbance

Sleep disturbance was assessed using the sleep subscale from the European Organisation for Research and Treatment of Cancer Quality of Life Core Questionnaire (EORTC QLQ-C30) [28]. The subscale includes a core item assessing sleep problems over the previous week ("Have you had any sleep problems in the past week?"). Responses are recorded using a 4-point Likert scale and linearly converted to a score ranging from 0 to 100. Higher scores indicate more severe sleep disturbance. This single item is commonly used in oncology research as a practical indicator of sleep problems and has demonstrated acceptable validity in this context [29].

2.6 Assessment Indicators of Pain Intensity

The pain intensity of patients was assessed using the Visual Analogue Scale (VAS). The scale consists of a horizontal line 100 mm long, with "no pain" (0 mm) and "most intense pain imaginable" (100 mm) marked at the two ends [30]. Subjects marked the corresponding positions on the line based on their average pain experience over the past

24 hours. The distance (in millimeters) from the marked point to the left end was measured by the researcher, which was the pain intensity score, ranging from 0 to 100. The higher the score, the more intense the pain. As a single-dimensional and sensitive self-report tool, VAS is widely used in clinical pain assessment because it is easy to operate and understand, and is especially suitable for quickly capturing changes in pain intensity. This study used VAS to quantitatively assess the changes in pain intensity of patients before and after the intervention, providing fundamental data for analyzing the association between pain catastrophizing and pain experience.

2.7 Quality of Life and Fatigue Assessment

Patients' quality of life and fatigue were assessed using the FACIT-F scale, a multidimensional instrument designed to evaluate both health-related quality of life and fatigue in patients with chronic conditions, including cancer [31]. The FACIT-F scale contains 40 items covering five core dimensions: physical well-being (7 items), social/family well-being (7 items), emotional health (6 items), functional well-being (7 items), and fatigue subscale (13 items). The Trial Outcome Index (TOI), a composite score derived from the physical well-being, functional well-being, and fatigue subscales, was also calculated. All items were scored using a 5-point Likert scale [31]. The scores for each dimension were calculated by summing, with the fatigue subscale having a total score range of 0–52 points, and the other four functional dimensions having a total score range of 0–28 points or 0–24 points, respectively. The total score range of the scale was 0–160 points. Higher scores indicate improved perceived quality of life and diminished fatigue. In this study, the total score of the scale and scores of key dimensions such as functional well-being and fatigue subscales were used to assess patients before and after the intervention, in order to comprehensively analyze the impact of the intervention on patients' overall quality of life and specific functional areas.

2.8 Data Analysis

Statistical analysis was performed using SPSS 27.0 software (IBM Corp., Armonk, NY, USA) to organize and statistically process the collected data. Before analysis, the distribution characteristics of continuous data were assessed using the Kolmogorov–Smirnov test. Variables conforming to a normal distribution were expressed as mean ± standard deviation (SD). Independent samples *t*-tests were used for comparisons between groups, whereas paired *t*-tests were used for comparisons before and after intervention within the same group. Continuous data not conforming to a normal distribution were expressed as median and interquartile ranges [M (Q_1, Q_3)]. Mann–Whitney *U* tests were used to analyze differences between groups, and Wilcoxon signed-rank tests were used for comparisons before and after intervention within the same group. Categorical data were expressed as percentages, and either the chi-square test or Fisher's exact test was used to compare differences between groups. Fisher's exact test was applied when the expected frequency in any cell of a 2 × 2 table was less than 1; otherwise, the chi-square test was used. All statistical tests were two-tailed, and a p-value < 0.05 was considered statistically significant. The statistical results were visualized using GraphPad Prism 10.1.2 software (GraphPad Software, San Diego, CA, USA).

3. Results

3.1 Comparison of Baseline Characteristics

A total of 187 lung cancer patients who underwent combined chemoradiotherapy were included in this study and divided into a control group (n = 109) and an observation group (n = 78) according to the intervention method. There were no statistically significant differences between the two groups in terms of age, BMI, sex, clinical stage, pathological type of tumor, comorbidities, region of residence, smoking status, analgesic use, or prior treatment history ($p > 0.05$). These results suggest that the baseline characteristics of the two groups were similar before the intervention, making them highly comparable (Table 1).

3.2 Comparison of Pain-Related Indicators

Before the intervention, there were no statistically significant differences in PCS or VAS scores between the two groups ($p > 0.05$). After the intervention, the mean PCS and VAS scores in the observation group were significantly lower than those in the control group ($p = 0.007$ and $p = 0.018$, respectively) (Table 2).

3.3 Comparison of Sleep Quality

As shown in Table 3, there were no statistically significant differences in sleep-related scores between the two groups before the intervention ($p > 0.05$). After the intervention, the EORTC score for the sleep subscale of the observation group was significantly lower than that of the control group ($p = 0.036$).

3.4 Comparison of Quality of Life

Regarding quality-of-life assessment, there were no statistically significant differences in scores across dimensions and total scores between the two groups before the intervention ($p > 0.05$), indicating comparable baseline levels. After the intervention, the observation group showed significant improvements across multiple dimensions of quality of life: their scores in physical well-being, social/family well-being, functional well-being, and emotional health were significantly higher than those in the control group ($p < 0.05$). In addition, the observation group reported significantly higher scores on the fatigue scale compared with the control group ($p = 0.028$). In terms of core quality-of-life indicators, the median TOI score in the observation group was significantly higher than that in the control group ($p <$

Table 2. Comparison of pain-related indicators.

Variables	Control group (n = 109)	Observation group (n = 78)	Statistic	p
PCS – Pre-Intervention	25.68 ± 11.79	24.85 ± 9.23	t = 0.541	0.589
PCS – Post-intervention	18.84 ± 7.89*	15.67 ± 7.80*	t = 2.729	0.007
VAS – Pre-intervention	31.24 ± 9.76	31.17 ± 8.04	t = 0.053	0.958
VAS – Post-intervention	26.31 ± 4.97*	24.28 ± 6.17*	t = 2.402	0.018

Notes: *$p < 0.05$, compared with pre-intervention within the same group.

Abbreviations: PCS, Pain Catastrophizing Scale; VAS, Visual Analogue Scale.

Table 3. Comparison in sleep quality between the control and observation groups.

Variables	Control group (n = 109)	Observation group (n = 78)	Statistic	p
EORTC-Sleep – Pre-intervention	45.11 ± 9.19	43.99 ± 7.52	t = 0.917	0.360
EORTC-Sleep – Post-intervention	41.50 ± 9.02*	39.15 ± 6.22*	t = 2.110	0.036

Notes: *$p < 0.05$, compared with pre-intervention within the same group.

Abbreviation: EORTC, European Organisation for Research and Treatment of Cancer.

Table 4. Comparison of quality of life between the control and observation groups.

Variables	Control group (n = 109)	Observation group (n = 78)	Statistic	p
Physical well-being status – Pre-intervention	14.90 ± 5.46	15.36 ± 5.83	t = –0.552	0.582
Physical well-being status – Post-intervention	17.60 ± 5.28*	19.01 ± 3.33*	t = –2.246	0.026
Social/Family well-being – Pre-intervention	15.91 ± 6.14	15.37 ± 6.35	t = 0.581	0.562
Social/Family well-being – Post-intervention, M (Q_1, Q_3)	18.00 (15.00, 22.00)*	21.50 (19.00, 24.00)*	Z = –4.396	<0.001
Functional well-being – Pre-intervention	12.58 ± 5.37	13.17 ± 5.23	t = –0.747	0.456
Functional well-being – Post-intervention	15.38 ± 5.52*	17.55 ± 5.10*	t = –2.742	0.007
Fatigue Scale – Pre-intervention	26.16 ± 8.45	27.86 ± 8.80	t = –1.335	0.183
Fatigue Scale – Post-intervention	29.85 ± 6.28*	32.28 ± 8.08*	t = –2.219	0.028
Emotional health – Pre-intervention, M (Q_1, Q_3)	12.00 (7.00, 17.00)	13.00 (7.00, 18.00)	Z = –0.350	0.726
Emotional health – Post-intervention, M (Q_1, Q_3)	15.00 (12.00, 16.00)*	17.50 (15.00, 20.00)*	Z = –5.025	<0.001
FACIT-F TOI – Pre-intervention, M (Q_1, Q_3)	56.00 (47.00, 65.00)	56.00 (49.25, 64.00)	Z = –0.440	0.660
FACIT-F TOI – Post-intervention, M (Q_1, Q_3)	65.00 (57.00, 72.00)*	75.00 (67.25, 83.00)*	Z = –5.528	<0.001
Total score – Pre-intervention, M (Q_1, Q_3)	82.00 (73.00, 91.00)	84.00 (76.25, 92.75)	Z = –1.295	0.195
Total score – Post-intervention, M (Q_1, Q_3)	96.00 (83.00, 104.00)*	105.50 (101.00, 115.75)*	Z = –5.743	<0.001

Notes: *$p < 0.05$, compared with pre-intervention within the same group. For within-group comparisons, The within-group comparison for Social/Family Well-being was analyzed using the Wilcoxon signed-rank test.

Abbreviation: TOI, Trial Outcome Index.

0.001). The total quality-of-life score was also significantly higher in the observation group than in the control group after the intervention ($p < 0.001$) (Table 4). The above results suggest that electromyographic biofeedback relaxation training was associated with better overall quality of life and performance in multiple functional areas of lung cancer patients undergoing combined chemoradiotherapy.

4. Discussion

Lung cancer is characterized by ever-increasing high incidence and mortality rates worldwide. The treatment for lung cancer often culminates in significant adverse reactions and psychological stress in patients [32]. Pain catastrophizing and fatigue are highly prevalent and distressing symptoms experienced by lung cancer patients undergoing chemoradiotherapy, which significantly impair their quality of life [33,34]. Crucially, their severity is modulated by psychological factors, with pain catastrophizing recognized as a key cognitive amplifier that exacerbates the sensory and emotional experience of pain [17,35]. Therefore, on the basis of routine anti-tumor treatment and symptomatic support, exploring intervention strategies that can act on both physiological and psychological levels is of great significance for optimizing patients' treatment experience and overall outcomes.

The results of this retrospective study suggest that electromyographic biofeedback relaxation training, as an adjunct intervention, can mitigate pain catastrophism, pain intensity, fatigue, and sleep disturbances, as well as improve quality of life, in lung cancer patients undergoing combined chemoradiotherapy. This adds to the empirical evidence for the application of biofeedback technology in the field of supportive cancer care. The concurrent reductions in pain catastrophizing and pain intensity sug-

gest that cognitive restructuring processes, facilitated by attention control and other non-pharmacological approaches, may contribute to a more modulated pain experience [36]. The potential mechanisms underlying these effects may involve both physiological and cognitive pathways. Physiologically, biofeedback training has been shown to reduce muscle tension and attenuate physiological arousal, thereby facilitating relaxation and symptom relief in cancer patients [37]. A recent scoping review further suggests that biofeedback improves autonomic balance and enhances psychological adaptability, contributing to better management of pain, fatigue, and sleep disturbances in oncology populations [38]. Cognitively, the training process may enhance patients' sense of self-efficacy—a factor that has been shown to predict improvements in quality of life following biofeedback interventions [37]. This sense of control may help counteract the helplessness central to pain catastrophizing, thereby disrupting the vicious cycle involving the interplay between pain, fatigue, and emotional distress.

This study found that the observation group had more favorable fatigue and sleep disturbance scores than the control group. The concurrent association with reduced fatigue and improved sleep quality suggests that biofeedback may be linked to a mitigation of the energy exhaustion and sleep disorders commonly encountered in patients undergoing combined chemoradiotherapy, potentially through the induction of a deeper state of physiological relaxation and regulation of autonomic nervous system balance. A previous study suggested that relaxation training and biofeedback intervention hold promise in the management of fatigue and sleep disorders in cancer patients, and the results of this study further support its applicability in the context of combined chemoradiotherapy [39]. At the same time, the findings of this study, measured using the FACIT-F subscale, lend further support to the potential benefit of electromyographic biofeedback training in mitigating fatigue levels among patients. The experimental results suggest that the observation group showed significant improvement in multiple functional dimensions and total score. One plausible reason is that interventions targeting symptom experience and cognitive patterns may positively impact the overall quality of life of patients through multiple pathways. Existing literature indicates that biofeedback intervention can improve pain, fatigue, and mood in patients with different tumor types and at varying treatment stages [37,40]. However, research regarding the impact of biofeedback intervention on multidimensional symptom outcomes in lung cancer patients undergoing combined chemoradiotherapy, particularly from the perspective of the psychological cognitive factor of pain catastrophizing, is still relatively limited.

Several limitations should be noted. First, this was a single-center retrospective study, which limits generalizability and may introduce selection bias. Second, the intervention period was short, precluding evaluation of long-term outcomes. Third, the non-randomized design precludes causal inference. Although baseline characteristics were comparable between groups (Table 1), unmeasured confounding factors—such as patients' motivation, psychological resilience, variations in routine supportive care, and concomitant usage of medications (e.g., drug classes, doses, or dose changes during the study)—could not be fully accounted for. Fourth, outcome measures relied on self-report scales, which are subject to subjective bias. Additionally, cost and insurance data were not collected, and the observation group included only patients who completed all six training sessions, which may not reflect real-world adherence. Future prospective studies that employ longer follow-up and objective physiological measures are warranted to confirm these findings.

5. Conclusion

In conclusion, this study found that electromyographic biofeedback relaxation training integrated into routine combined chemoradiotherapy management mitigated pain catastrophizing and fatigue levels, improved sleep quality, and enhanced overall quality of life in lung cancer patients. Thus, this intervention strategy represents a safe, feasible, and comprehensive non-pharmacological approach for symptom management in lung cancer patients undergoing combined chemoradiotherapy, meriting further evaluation and validation in clinical practice.

Key Points

• This retrospective cohort study included 187 lung cancer patients receiving chemoradiotherapy, with 78 patients in the observation group who completed six sessions of electromyographic biofeedback relaxation training over two weeks and 109 patients in the control group who received routine supportive care only.

• After the intervention, the observation group showed significantly greater improvements than the control group in pain catastrophizing, pain intensity, fatigue, sleep disturbance, and multiple dimensions related to quality of life, with within-group analyses also revealing significant improvements after intervention in both groups.

• Electromyographic biofeedback relaxation training is a safe and feasible non-pharmacological intervention for symptom management in lung cancer patients undergoing chemoradiotherapy, although retrospective study design, short intervention period, and lack of detailed medication data should be considered when interpreting the findings.

Availability of Data and Materials

The datasets generated during and analysed during the current study are available from the corresponding author on reasonable request.

Author Contributions

WYW and XLF designed the research study. WYW, LYC, JJH, YLW and FY performed the research. WYW, HWW and XNL analyzed the data. WYW and XLF drafted this article. All authors contributed to the important editorial changes in the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

This study was conducted in strict adherence to the principles of the Declaration of Helsinki and was approved by the Ethics Committee of Haikou Affiliated Hospital of Central South University Xiangya School of Medicine (Approval No.: 2022-106). Owing to the retrospective nature of this research and the use of de-identified data extracted from existing medical records, the requirement to obtain individual informed consent from patients was waived by the Ethics Committee, as the study posed no more than minimal risk to participants. All data were kept strictly confidential and used solely for this study.

Acknowledgment

Not applicable.

Funding

This project was supported by Hainan Provincial Natural Science Foundation of China (No. 823RC611).

Conflicts of Interest

The authors declare no conflicts of interest.

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