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Impact of a functional food–oriented self-care educational program on physical activity and treatment tolerance in lung cancer patients undergoing chemotherapy

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ABSTRACT

Background: Cancer-related fatigue and reduced treatment tolerance are among the most debilitating consequences of chemotherapy in lung cancer patients. Emerging evidence highlights the role of functional foods and bioactive dietary components in modulating inflammation, oxidative stress, and metabolic dysfunction—key mechanisms underlying fatigue and physical decline during cancer treatment.

Objectives: To evaluate the impact of a functional food–based self-care educational program on physical activity, fatigue, and chemotherapy tolerance among lung cancer patients.

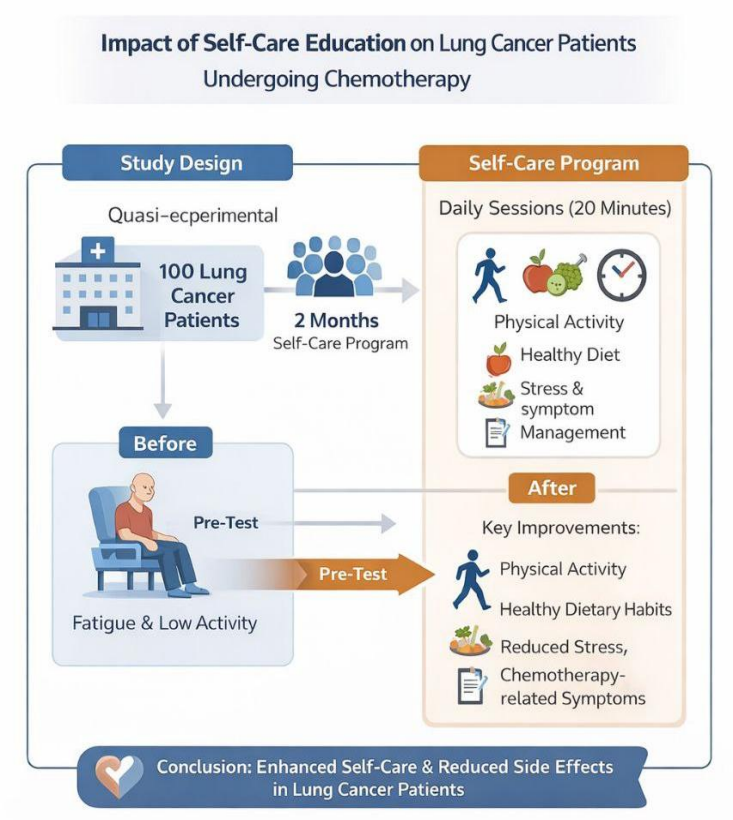
Methods: A quasi-experimental pre–post study was conducted among 100 lung cancer patients undergoing chemotherapy. Participants received a structured self-care educational program emphasizing functional food principles, including antioxidant-rich foods, omega-3 fatty acids, and high-quality protein sources, alongside guidance on physical activity and symptom management. Outcomes related to physical activity, fatigue severity, and chemotherapy-related symptoms were assessed before and after the intervention.

Results: The intervention resulted in significant improvements in physical activity engagement and health-related behaviors. Notable reductions were observed in chemotherapy-related fatigue, gastrointestinal symptoms, peripheral neuropathy, and analgesic use ($p < 0.05$). Improved treatment tolerance was accompanied by enhanced dietary practices consistent with functional food recommendations.

Novelty of the Study: This study provides region-specific evidence from Iraq on the clinical impact of a structured functional food–oriented educational intervention in lung cancer patients, linking bioactive dietary principles with symptom reduction and improved chemotherapy tolerance.

Conclusion: A functional food–based self-care educational program significantly improved physical activity levels, reduced treatment-related symptoms, and enhanced chemotherapy tolerance in lung cancer patients. These findings support the integration of functional nutrition strategies into supportive oncology care to improve clinical and functional outcomes.

Keywords: Functional foods; Bioactive compounds; Lung cancer; Chemotherapy tolerance; Cancer-related fatigue; Physical activity.



Graphical Abstract: Study design and outcomes of the educational self-care program.

INTRODUCTION

Lung cancer is one of the leading causes of cancer-related mortality worldwide, with non-small cell lung cancer (NSCLC) representing nearly 85% of all cases [1]. Despite advances in treatment, chemotherapy remains a cornerstone of management but is frequently associated with burdensome side effects such as fatigue, nausea, vomiting, appetite loss, and gastrointestinal disturbances that significantly impair patients' functional capacity and quality of life [2,7]. Fatigue is particularly debilitating and is influenced by multiple clinical and psychological factors [7].

Recent evidence indicates that functional foods and bioactive dietary components including antioxidants, omega-3 fatty acids, polyphenols, and probiotic-rich foods play a pivotal role in modulating inflammation, oxidative stress, and muscle metabolism in cancer patients. These mechanisms are directly associated with fatigue severity, physical performance, and tolerance to chemotherapy [21–29]. Nutritional strategies incorporating bioactive compounds such as polyphenols, isothiocyanates, sulforaphane, and resveratrol have been associated with improved inflammatory profiles, metabolic regulation, and symptom control in oncology populations [21–24,27].

Regular physical activity has been shown to reduce fatigue, improve muscle strength, and enhance overall well-being among patients undergoing chemotherapy [5,8]. However, many patients remain inactive due to fear of symptom exacerbation or limited awareness of safe exercise practices during treatment. Likewise, diets rich in antioxidants, high-quality proteins, vitamins, and functional foods have been shown to support immune function and reduce treatment-related complications [18,19,30].

Educational self-care programs have emerged as effective strategies for empowering cancer patients by improving health literacy, promoting healthier behaviors, and enhancing symptom-management skills [15,16]. Integrating functional food principles within structured self-care interventions may therefore address both biological and behavioral determinants of treatment tolerance.

Given the high burden of chemotherapy-related symptoms and the importance of lifestyle behaviors in treatment outcomes, this study aimed to evaluate the effect of a functional food-oriented self-care educational program on physical activity, fatigue severity, chemotherapy-related symptoms, and health-related behaviors among lung cancer patients undergoing chemotherapy.

METHODOLOGY

Study Design and Setting: A quasi-experimental pre-test–post-test design was conducted at Nanakaly Oncology Hospital in Erbil, Kurdistan Region of Iraq. Ethical approval was granted by the Institutional Ethical Committee (Code No. 251/18; Date: 05/03/2024).

Sample Size and Sampling Technique: A total of 100 lung cancer patients were recruited using non-probability purposive sampling. Sample size calculation was performed according to the formula proposed by Chow et al. [31].

Inclusion and Exclusion Criteria

Inclusion criteria:

- Diagnosed with NSCLC or SCLC
- Receiving second or third chemotherapy cycle
- Able to read and understand educational materials
- Willing to participate

Exclusion criteria:

1. Severe cognitive impairment
2. Advanced terminal illness
3. Conditions independently influencing fatigue

Intervention: Self-Care Education Program

The educational program was delivered over two months and included structured daily sessions (20 minutes each).

The dietary component of the program was designed according to functional food principles. Patients received guidance on consuming bioactive-rich foods, including antioxidant-containing fruits and vegetables, omega-3 fatty acid sources, high-quality proteins, and hydration strategies aimed at reducing inflammation, supporting muscle function, and enhancing chemotherapy tolerance.

The program focused on:

Physical activity guidance: energy conservation, pacing, and light aerobic exercises.

Healthy dietary recommendations: balanced nutrition, hydration, and foods that enhance energy and treatment tolerance.

Stress and symptom management: breathing exercises, relaxation techniques, and coping strategies.

Participants received brochures and a fatigue diary and were encouraged to perform walking or stretching exercises twice daily for 20 minutes.

Data Collection Tools: Data were collected using the following instruments:

A demographic and clinical data sheet

A clinical profile form

The Brief Fatigue Inventory (BFI)—a validated tool assessing fatigue severity and its effect on daily activities

Validity of the Instruments: Content validity was reviewed by a panel of 15 experts with 17–30 years of experience in oncology, nursing, and medical education. Their suggestions were incorporated to ensure clarity, relevance, and adequacy of the instruments.

Data Collection Procedure: Data collection was carried out from 05/08/2024 to 05/10/2024. Pre-test measurements were obtained before commencing the intervention, while post-test assessments were conducted four weeks after the program's completion.

Ethical Considerations: Participants were informed about the study objectives and procedures, and written informed consent was obtained. Confidentiality and anonymity were ensured. Participation was voluntary, and patients were allowed to withdraw at any time without consequences.

Statistical Analysis: Data were analyzed using descriptive statistics (means and standard deviations) to summarize demographic and clinical characteristics. Paired t-tests were employed to compare pre- and post-intervention fatigue scores. McNemar's test was used to analyze paired categorical variables, including changes in health behaviors and clinical symptoms before and after the intervention. A p-value < 0.05 was considered statistically significant. All analyses were performed using R software.

RESULTS AND DISCUSSION

Table 1 summarizes the socio-demographic characteristics of the study participants. The majority were male (79%), whereas females constituted 21%, indicating a clear gender predominance among lung cancer patients in this sample. Most participants were older adults, with 60% aged 60–70 years and 31% aged 50–59 years, reflecting the typical age distribution of lung cancer. Younger age groups were minimally represented, accounting for less than 5% of the sample.

The educational profile of participants showed generally low formal education levels, as 70% were literate without formal schooling. Only a minority had completed primary school (7%), secondary school (11%), or university education (12%). Regarding occupation, the largest groups were retired clerical workers (38%) and housewives (20%), followed by clerical employees (15%) and professionals (18%), while laborers represented 9%.

All participants were married, and no individuals reported single, divorced, or widowed status. Most participants (86%) reported sufficient income, indicating overall financial stability, whereas 14% expressed inadequate income. Additionally, the majority resided in urban areas (68%), with 32% living in rural settings, suggesting greater access to healthcare services among urban residents.

Table 1. Frequency Distribution of Lung Cancer Patients Undergoing Chemotherapy According to Their Socio-Demographic Characteristics.

Patient's socio-demographic characteristics	Study(n = 100)	
	No.	%
Gender		
Female	21	21.0
Male	79	79.0
Age		
20-29	1	1.0
30-39	2	2.0
40-49	6	6.0
50-59	31	31.0
60-70	60	60
Level of Education		
Read &write	70	70.0
Primary	7	7.0
Secondary	11	11.0
University	12	12.0
Occupation		
Laborer	9	9.0
Clerical	15	15.0
Professional	18	18.0
Housewife	20	20.0
Retired Clerical	38	38.0
Marital Status		
Single	0	0.0
Married	100	100.0
Divorced	0	0.0
Widow	0	0.0
Income		
Sufficient	86	86.0
Insufficient	14	14.0
Residence Area		
Rural	32	32.0
Urban	68	68.0

Table 2 presents the ECOG performance status of lung cancer patients undergoing chemotherapy. Most patients (65%) were classified as fully active and able to perform all pre-disease activities without restriction, indicating that a large proportion maintained adequate functional capacity during treatment. Additionally, 32%

were ambulatory and capable of performing light or sedentary activities, reflecting mild-to-moderate functional limitations commonly observed among patients receiving chemotherapy.

Only a small proportion (3%) were ambulatory but unable to carry out work-related tasks, suggesting more advanced physical impairment. Notably, none of the patients were categorized within ECOG grades 3–5, indicating that the study sample primarily included individuals who were physically stable enough to undergo chemotherapy.

Overall, these findings demonstrate that most patients retained sufficient functional status to engage in essential daily activities. This has important implications for supportive care planning, including physical activity recommendations and nutritional strategies that may help maintain or improve performance status throughout chemotherapy.

Table 2: Eastern Cooperative Oncology Group (ECOG) Performance Status of Lung Cancer Patients Undergoing Chemotherapy.

Items		Frequency	Valid Percent
Valid	Fully active, able to carry on all pre-disease performance without restriction	65	65.0
	Restricted in physically strenuous activity but ambulatory and able to carry out work of a light or sedentary nature	32.0	32.0
	Ambulatory and capable of all self-care but unable to carry out any work activities	3	3.0
	Total	100.0	100.0

Table 3 summarizes the clinical characteristics of lung cancer patients undergoing chemotherapy. The onset of disease varied across several months, with the highest proportion reported in February 2024 (33%), followed by April (22%) and September (12%). Diagnosis was most frequently established in May 2024 (33%), indicating a noticeable delay between the emergence of symptoms and clinical confirmation for many patients. Chemotherapy was initiated for most patients in June 2024 (34%), reflecting ongoing treatment patterns within this cohort.

Most participants (85%) had no history of chronic illness, whereas 15% reported comorbidities such as hypertension (4%) and diabetes (6%), or combined conditions including diabetes with anemia or skin disease. These comorbidities may influence treatment tolerance, fatigue severity, and nutritional needs during chemotherapy.

Chemotherapy-related side effects were common and varied in severity. Nausea and vomiting were the most frequently reported (53%), followed by hair loss (40%), fatigue (24%), and loss of appetite (10%). Gastrointestinal disturbances—including diarrhea and constipation—were documented in 46% of patients, while oral infections occurred in 5%. Fever and skin discoloration were present in 10% and 41.5% of the sample, respectively, demonstrating the broad spectrum of treatment-related toxicities.

Peripheral pain (52%) and numbness (46%) were frequently reported, suggesting a high prevalence of chemotherapy-induced neuropathy, which may negatively impact physical activity and daily functioning. A previous history of cancer was noted in 23% of participants, while 11% reported a family history of lung cancer, indicating possible genetic or environmental predisposition.

Nearly half of the patients (48%) used analgesics for symptom management, most commonly Paracetamol (30%) and Tramadol (11%). This underscores the ongoing need for supportive interventions—including pain management, nutrition support, and fatigue reduction strategies—to improve treatment tolerance and overall quality of life during chemotherapy.

Table 3: Frequency Distribution of Lung Cancer Patients Undergoing Chemotherapy According to Clinical Characteristics

Table 3A. Disease Timeline of Lung Cancer Patients (n = 100)

Variable	n	%
Onset of Disease - 11/01/2022	11	11.0
Onset of Disease - 01/27/2024	11	11.0
Onset of Disease - 02/01/2024	33	33.0
Onset of Disease - 03/01/2024	11	11.0
Onset of Disease - 04/01/2024	22	22.0
Onset of Disease - 09/01/2024	12	12.0
Date of Diagnosis - 12/01/2022	32	32.0
Date of Diagnosis - 01/01/2023	19	19.0
Date of Diagnosis - 04/01/2023	16	16.0
Date of Diagnosis - 05/01/2024	33	33.0
Start of Chemotherapy - 01/01/2024	33	33.0
Start of Chemotherapy - 04/01/2024	33	33.0
Start of Chemotherapy - 06/05/2024	34	34.0

Table 3B. Clinical Characteristics and Comorbidities (n = 100)

Variable	n	%
History of Chronic Disease - Yes	15	15.0
History of Chronic Disease - No	85	85.0
Hypertension	4	4.0
Diabetes	6	6.0
Diabetes + Hypertension	3	3.0
Diabetes + Anemia + Skin Disease	2	2.0
Previous Cancer History - Yes	23	23.0
Previous Cancer History - No	77	77.0
Family History of Lung Cancer - Yes	11	11.0
Family History of Lung Cancer - No	89	89.0
Use of Analgesics - Yes	48	48.0
Use of Analgesics - No	52	52.0
Paracetamol	30	30.0
Tramadol	11	11.0
Anti-allergy	2	2.0

Table 3C. Chemotherapy-Related Side Effects (n = 100)

Symptom	n	%
Nausea and Vomiting	53	53.0
Hair Loss	40	40.0
Fatigue	24	24.0
Decreased Appetite	10	10.0
Diarrhea / Constipation	46	46.0
Mouth Infection	5	5.0
Fever	10	10.0
Skin Discoloration	41	41.0
Peripheral Pain	52	52.0
Numbness	46	46.0

Table 4 demonstrates the effect of the educational self-care program on the clinical symptoms and treatment-related side effects among 100 lung cancer patients undergoing chemotherapy. A clear improvement was observed across multiple health indicators when comparing pre- and post-intervention results. Statistically significant reductions ($p < 0.05$) were noted in nausea and vomiting (23% decrease), fatigue

(9% decrease), diarrhea and constipation (18% decrease), skin discoloration (11% decrease), peripheral pain (14% decrease), numbness (16% decrease), and the use of analgesics (15% decrease).

These findings indicate that the educational program played an important role in enhancing patients' symptom-management abilities. Improved outcomes are likely related to increased patient knowledge, better adherence to self-care recommendations, incorporation of healthier dietary behaviors, and earlier reporting of symptoms during chemotherapy. Collectively, the results suggest that structured self-care education can significantly improve physical well-being and reduce the burden of chemotherapy-related side effects in lung cancer patients.

Table 4: Comparison of Health Status Before and After the Educational Program Among Lung Cancer Patients (n = 100)

Health Issues / Symptoms	Pre-Education n (%)	Post-Education n (%)	Change	p-value
Nausea and Vomiting	53 (53%)	30 (30%)	↓ 23%	0.001*
Hair Loss	40 (40%)	35 (35%)	↓ 5%	0.210
Fatigue	24 (24%)	15 (15%)	↓ 9%	0.045*
Decreased Appetite	10 (10%)	6 (6%)	↓ 4%	0.317
Diarrhea and Constipation	46 (46%)	28 (28%)	↓ 18%	0.003*
Mouth Infection	5 (5%)	3 (3%)	↓ 2%	0.564
Fever	10 (10%)	5 (5%)	↓ 5%	0.174
Skin Discoloration	41 (41%)	30 (30%)	↓ 11%	0.026*
Peripheral Pain	52 (52%)	38 (38%)	↓ 14%	0.015*
Numbness	46 (46%)	30 (30%)	↓ 16%	0.009*
Use of Painkillers (any)	48 (48%)	33 (33%)	↓ 15%	0.012 *

$p < 0.05$ (statistically significant)

Table 5 presents the distribution of five essential health behaviors—smoking cessation, physical activity, healthy diet, stress management, and sleep quality—assessed before and after a structured educational program among 100 lung cancer patients undergoing chemotherapy. The findings indicate statistically significant improvements across all behavioral domains as assessed by McNemar's Chi-square test for paired data.

A substantial improvement was observed in smoking cessation. Before the intervention, all patients were active smokers; however, 58% reported quitting smoking after the program ($p = 0.001$), underscoring the effectiveness of the educational intervention in modifying a major risk factor associated with lung cancer progression and treatment outcomes.

Engagement in physical activity also increased markedly, rising from 22% pre-intervention to 61% post-intervention ($p = 0.004$). This improvement highlights the program's positive influence in promoting regular exercise, which is essential for maintaining functional capacity, mitigating fatigue, and supporting overall well-being during chemotherapy.

Healthy dietary practices showed significant enhancement. Only 18% adhered to a healthy diet before the program, compared to 64% afterward ($p = 0.002$). This indicates that the educational program effectively encouraged patients to adopt nutritious eating patterns that support immune function, treatment tolerance, and overall nutritional status.

Stress management exhibited notable improvement as well. Positive coping responses increased from 15% prior to the intervention to 63% afterward ($p = 0.0005$), suggesting that the program successfully provided patients with practical psychological and behavioral strategies to manage stress during treatment.

Sleep quality also improved substantially. While 31% of patients reported good sleep before the program, this increased to 74% following the intervention (p = 0.001). These results reflect enhanced sleep hygiene practices promoted through the educational sessions, contributing to better recovery, reduced fatigue, and improved psychological stability.

Table 5: Health Behaviors of Lung Cancer Patients (Pre- and Post-Educational Program).

Health Behavior	Pre: Positive	Pre: Negative	Post: Positive	Post: Negative	p-value
1. Smoking Cessation	0	100	58	42	0.001
2. Physical Activity	22	78	61	39	0.004
3. Healthy Diet	18	82	64	36	0.002
4. Stress Management	15	85	63	37	0.0005
5. Sleep Quality	31	69	74	26	0.001

Discussion: The findings of the present study demonstrate that a functional food–based self-care educational program significantly improved physical activity, health-related behaviors, and chemotherapy tolerance among lung cancer patients. These findings are consistent with prior research highlighting the role of lifestyle interventions in reducing symptom burden during cancer treatment [15-16,18].

The reduction in cancer-related fatigue observed in this study is clinically meaningful. Fatigue is strongly associated with inflammation, oxidative stress, and metabolic dysregulation [7]. Functional foods rich in antioxidants and omega-3 fatty acids may modulate inflammatory pathways and oxidative stress mechanisms, potentially contributing to improved energy levels and functional status [21–24,27].

The significant increase in physical activity aligns with evidence showing that exercise reduces fatigue and enhances quality of life in lung cancer patients undergoing chemotherapy [8–11,14]. Nutritional adequacy, particularly adequate protein and bioactive compound intake, supports muscle metabolism and recovery, thereby facilitating greater physical engagement [18-19,30].

Additionally, reductions in chemotherapy-related toxicities including nausea, gastrointestinal disturbances, neuropathy, and analgesic use may reflect improved self-management behaviors and dietary modulation of oxidative and inflammatory processes [21,25–29].

Although alopecia and infections showed limited responsiveness, these outcomes are largely driven by direct cytotoxic mechanisms [3]. Future studies incorporating objective inflammatory or oxidative stress biomarkers would further clarify the biological mechanisms underlying functional food–based supportive interventions [21,27,30].

FFC Framework: The present findings align with key elements of the Functional Food Center (FFC) 17-step framework. The intervention corresponds to Step 3 (mechanistic understanding), as it targets inflammation and oxidative stress pathways through bioactive dietary components. It also reflects Step 5 (clinical relevance of functional endpoints), as fatigue reduction and improved treatment tolerance represent clinically meaningful outcomes. Furthermore, this quasi-experimental study contributes to Step 6 (clinical validation), providing supportive evidence for functional food-oriented strategies in oncology care.

Strengths and Limitations: This study has several notable strengths. First, it adopts an integrative approach that combines functional food–based nutritional education with physical activity and symptom-management strategies, addressing both behavioral and biological determinants of chemotherapy tolerance. This

multidimensional framework aligns closely with emerging evidence emphasizing the role of bioactive dietary components in modulating inflammation, oxidative stress, and treatment-related toxicity [18,21–24]. Second, the study was conducted in a real-world clinical oncology setting, enhancing the practical relevance and applicability of the findings to routine supportive cancer care. Third, the inclusion of multiple outcome domains—including physical activity, symptom burden, and health-related behaviors—provides a comprehensive evaluation of the intervention's impact.

Despite these strengths, several limitations should be acknowledged. The quasi-experimental pre–post design without a control group limits the ability to establish causal relationships and may be subject to potential confounding factors [31]. The use of purposive sampling and a single-center setting may restrict the generalizability of the findings to broader lung cancer populations. Additionally, outcomes were primarily assessed using self-reported measures, which may introduce reporting bias. The absence of objective biomarkers—such as inflammatory cytokines, oxidative stress markers, or nutritional status indicators—limits direct mechanistic interpretation of the observed effects of functional food–based education [21,27,30].

Future research should employ randomized controlled designs with larger and more diverse samples to confirm these findings and strengthen causal inference. Incorporating biological markers and longitudinal follow-up would further elucidate the mechanistic pathways through which functional foods and bioactive compounds influence fatigue, physical function, and chemotherapy tolerance.

CONCLUSION

This study demonstrates that a structured educational self-care program can significantly improve both health outcomes and health-related behaviors among lung cancer patients undergoing chemotherapy. The program was associated with meaningful improvements in smoking cessation, physical activity, adherence to a healthy diet, stress management, and sleep quality—behaviors that are essential for comprehensive supportive care. In addition, the intervention contributed to a significant reduction in several chemotherapy-related symptoms, including nausea, fatigue, gastrointestinal disturbances, and neuropathy.

While some treatment-related effects such as hair loss and infections showed limited responsiveness to behavioral interventions, overall findings highlight the value of integrating patient-centered educational strategies into routine oncology practice to enhance functional status, treatment tolerance, and quality of life.

Recommendations: Based on the study findings, integrating structured educational self-care programs into routine oncology services is recommended to support healthier behaviors and improve symptom management among lung cancer patients. Further research involving larger and more diverse populations is encouraged to validate the long-term impact of such interventions.

List of Abbreviations: NSCLC, non-small cell lung cancer; SCLC, small cell lung cancer; BFI, Brief Fatigue Inventory; ECOG, Eastern Cooperative Oncology Group.

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