

Article

Effects of mindfulness-based interventions on anxiety and functional recovery in head and neck cancer patients undergoing radiotherapy: A prospective study

Boxiang Zhang¹, Boyang Li², Zhiyuan Liang³, Yuanyuan Zhang³, Lucy Yue Lau⁴, Yi Chen¹, Xiangyue Zeng^{1,*}¹ The Affiliated Cancer Hospital of Xinjiang Medical University, Urumqi 830011, China² The First Clinical School of Medicine, Zhengzhou University, Zhengzhou 450001, China³ Radiotherapy Department of Guizhou Provincial Tumor Hospital, Guiyang 550002, China⁴ Department of Public health, Harvard Medical School, Boston 02115, MA, USA*** Corresponding author:** Xiangyue Zeng, zxy20210912@163.com**CITATION**

Zhang B, Li B, Liang Z. Effects of mindfulness-based interventions on anxiety and functional recovery in head and neck cancer patients undergoing radiotherapy: A prospective study. *Psycho-Oncologie*. 2025; 19(3): 4522.
<https://doi.org/10.18282/po4522>

ARTICLE INFO

Received: 26 May 2025

Revised: 29 June 2025

Accepted: 14 July 2025

Available online: 29 September 2025

COPYRIGHT

Copyright © 2025 by author(s).

Psycho-Oncologie is published by PiscoMed Publishing Pte. Ltd. This work is licensed under the Creative Commons Attribution (CC BY) license.<https://creativecommons.org/licenses/by/4.0/>

Abstract: Patients with head and neck malignancies frequently experience substantial psychological distress and functional impairment during radiotherapy, yet structured interventions targeting both domains are lacking. This prospective controlled study evaluated the effectiveness of an 8-week mindfulness-based intervention (MBI) program on anxiety and functional recovery in individuals undergoing curative radiotherapy. A total of 100 eligible patients were enrolled and assigned to either the MBI group or a control group receiving standard care. The MBI group participated in weekly guided sessions and daily home practice. Anxiety and functional status were assessed at baseline, post-treatment, and 3-month follow-up using the Hospital Anxiety and Depression Scale – Anxiety subscale (HADS-A) and the Functional Assessment of Cancer Therapy – Head and Neck (FACT-H&N) questionnaire. Compared to controls, the MBI group demonstrated significantly greater reductions in anxiety and improvements in functional outcomes at both post-treatment and follow-up ($P < 0.01$). Adherence to the program was high, with 84% of participants completing ≥ 6 sessions, and satisfaction scores averaged 8.9/10. No adverse events were reported. A moderate negative correlation was observed between anxiety and function at follow-up ($r = -0.52$, $P < 0.01$), supporting a dual-benefit effect. These findings suggest that mindfulness-based interventions are feasible, well-accepted, and clinically beneficial in reducing emotional distress and supporting functional rehabilitation during radiotherapy. The results advocate for the integration of structured psychosocial approaches into comprehensive cancer care, particularly in high-risk populations.

Keywords: psychological distress; head and neck cancer radiotherapy; functional rehabilitation; integrative oncology; emotional resilience; behavioral intervention; cancer survivorship; anxiety management

1. Introduction

Head and neck cancer (HNC) represents a significant global health burden, accounting for more than 650,000 new cases and 330,000 deaths annually worldwide [1]. The majority of patients with HNC require multimodal treatment, including surgery, chemotherapy, and especially radiotherapy, which remains a cornerstone of organ preservation and curative-intent therapy [2]. Despite advances in radiation techniques and supportive care, patients with HNC often experience substantial physical and psychological distress during and after treatment. The anatomical complexity of the head and neck region, coupled with the side effects of radiation such

as mucositis, xerostomia, dysphagia, and voice alterations, frequently leads to impaired communication, eating difficulties, and visible disfigurement [3]. These changes significantly disrupt patients' social interaction, self-image, and functional independence, contributing to long-lasting quality-of-life deficits. Psychological comorbidities are highly prevalent in this population. Anxiety is one of the most common psychiatric symptoms in HNC patients, with studies reporting clinically significant anxiety levels in up to 30–40% of individuals undergoing treatment [4–6]. This emotional distress is often exacerbated during radiotherapy, a physically demanding and emotionally taxing phase, where patients may experience fear of recurrence, procedural anxiety, and existential concerns [7,8]. Moreover, anxiety and psychological burden are known to negatively influence treatment adherence, symptom perception, immune response, and ultimately, clinical outcomes. In parallel, functional recovery—defined as the regaining of physical, speech, nutritional, and social capabilities—is a central goal of rehabilitation in HNC patients. However, the relationship between psychological distress and functional outcomes remains underexplored in this group. There is a growing recognition that effective cancer rehabilitation requires not only addressing physical symptoms but also integrating psychological support throughout the treatment continuum. Consequently, there is a critical need to identify feasible, evidence-based interventions that can mitigate anxiety while supporting functional rehabilitation in patients with head and neck cancer undergoing radiotherapy.

Mindfulness-based interventions (MBIs) are structured programs that cultivate a nonjudgmental awareness of the present moment through practices such as breathing exercises [9], body scanning, mindful movement, and meditation. These interventions aim to enhance emotional regulation, reduce rumination, and foster acceptance-based coping, making them particularly well-suited for individuals confronting chronic illness and psychological distress. In oncology, MBIs have gained growing attention as supportive care strategies that may alleviate the emotional and functional burdens associated with cancer diagnosis and treatment [10]. A growing body of evidence supports the efficacy of MBIs in reducing anxiety, depression, and cancer-related fatigue, particularly among patients with breast, prostate, and colorectal cancer [11–14]. Randomized controlled trials and meta-analyses have shown that mindfulness training can lead to statistically and clinically meaningful improvements in psychological well-being, sleep quality, and health-related quality of life (HRQoL) [15,16]. Proposed mechanisms include modulation of the hypothalamic-pituitary-adrenal (HPA) axis, dampening of inflammatory pathways, and improvements in cognitive appraisal and behavioral flexibility [17]. Moreover, MBIs are generally low-risk, cost-effective, and adaptable to group or individual formats, including digital delivery [18]. Despite these promising findings, there remains a critical gap in applying and evaluating MBIs specifically in patients with HNC. This population is uniquely vulnerable due to the complex intersection of functional impairments—such as dysphagia, speech difficulties, and body image concerns—and heightened emotional distress during radiotherapy. Few studies have prospectively investigated the impact of MBIs in this setting, and even fewer have simultaneously assessed both psychological and functional outcomes. Given the synergistic interaction between mental health and physical recovery, a dual-outcome framework is essential to capture

the full therapeutic potential of MBIs. Furthermore, existing research in HNC patients has been limited by small sample sizes, heterogeneous interventions, and a lack of standardized outcome measures. To date, no prospective controlled trials have systematically evaluated an 8-week MBI program delivered during the course of radiotherapy in a homogeneous HNC cohort using validated tools such as the Hospital Anxiety and Depression Scale (HADS-A) [19] and the Functional Assessment of Cancer Therapy – Head and Neck (FACT–H&N) [20]. This study seeks to address this knowledge gap by assessing the feasibility and efficacy of MBIs in this high-risk and under-researched patient population.

Given the high prevalence of anxiety and functional impairments among HNC patients undergoing radiotherapy, coupled with the scarcity of targeted psychological interventions in this population, there is a compelling need to explore integrative, patient-centered strategies that can address both emotional and physical domains of recovery. MBIs, with their dual emphasis on psychological resilience and self-regulation, offer a theoretically sound and practically feasible approach. However, to date, few methodologically rigorous studies have evaluated the clinical impact of MBIs in HNC patients during the active phase of radiotherapy. The present study was designed as a prospective controlled trial to assess the effects of an 8-week mindfulness-based intervention on anxiety levels and functional recovery in HNC patients receiving curative-intent radiotherapy. The intervention was delivered in a structured format, combining weekly in-person mindfulness training sessions with guided daily home practice. Outcomes were assessed using validated instruments: the HADS-A for psychological distress, and the FACT–H&N for overall functional status. Measurements were taken at baseline, post-radiotherapy, and 3-month follow-up to capture both short- and intermediate-term effects. We hypothesized that patients in the intervention group would demonstrate significantly greater reductions in anxiety and improvements in functional outcomes compared to those receiving standard care alone. In addition to evaluating efficacy, we also aimed to assess the feasibility, adherence, and acceptability of the mindfulness program within a clinical radiotherapy schedule—a key consideration for real-world implementation. This study is among the first to apply a dual-outcome framework in a well-defined HNC cohort during radiotherapy and to examine the longitudinal impact of MBIs using both psychological and functional metrics. By addressing a critical gap in psycho-oncological care, our findings aim to inform future integrative rehabilitation models and support the inclusion of evidence-based mindfulness practices in comprehensive cancer care protocols.

2. Materials and methods

2.1. Study design and participants

This study was conducted as a prospective, controlled, non-randomized design to evaluate the effectiveness of an 8-week MBI in reducing anxiety and improving functional outcomes among patients with HNC undergoing radiotherapy. The study took place at the Radiotherapy Department of Guizhou Provincial Tumor Hospital, between January and December 2024. Ethical approval was obtained from the institutional review board (No. GZPTH-KY-20230142), and all participants provided

written informed consent prior to enrollment. Patients were eligible for inclusion if they were aged between 18 and 75 years, had a histologically confirmed diagnosis of squamous cell carcinoma of the head and neck region, and were scheduled to receive curative-intent radiotherapy with or without concurrent chemotherapy. Additional inclusion criteria included a Karnofsky Performance Status (KPS) score of ≥ 70 and the ability to understand and participate in structured psychological interventions. Exclusion criteria were as follows: current diagnosis of a major psychiatric disorder requiring medication, previous participation in mindfulness or meditation-based programs, evidence of distant metastasis, or significant cognitive impairment. Eligible patients were assigned to either the MBI group or the control group based on their preference and availability for intervention sessions. While this pragmatic allocation approach allowed for efficient implementation in a clinical setting, it introduces a potential risk of selection bias and limits causal inference, which should be considered when interpreting the results. Baseline demographic and clinical characteristics were collected prior to the start of radiotherapy.

2.2. Intervention

Participants in the intervention group received an 8-week structured mindfulness-based intervention (MBI) program designed specifically for cancer patients undergoing radiotherapy. The program was adapted from the Mindfulness-Based Stress Reduction (MBSR) and Mindfulness-Based Cognitive Therapy (MBCT) protocols, and delivered by a licensed clinical psychologist with formal mindfulness training certification. Sessions were conducted once per week in a small-group format (6–10 patients per group), with each session lasting approximately 60 min. The weekly curriculum included core components such as mindful breathing, body scanning, sitting meditation, walking meditation, and exercises focused on emotional regulation and acceptance. In addition to in-person sessions, participants were encouraged to engage in 15–20 min of daily home practice using guided audio recordings and written instructions. Compliance with home practice was recorded using patient-completed logs, which were reviewed weekly. Participants in the control group received standard care, which included routine oncologic management, nutritional counseling, and access to general psychological support services if needed, but no structured mindfulness or behavioral intervention was offered during the study period. All participants in both groups continued to receive their planned oncologic treatments without modification due to study participation. Fidelity to the intervention protocol was monitored through facilitator checklists and session attendance records.

2.3. Outcome measures

The primary outcomes of this study were anxiety levels and functional status, measured using validated, self-reported questionnaires administered at three time points: baseline (T0), immediately after completion of radiotherapy (T1), and at 3-month follow-up (T2). Anxiety was assessed using the HADS-A, a widely used screening tool designed to measure symptoms of generalized anxiety in medically ill populations. The HADS-A consists of seven items rated on a 4-point Likert scale, with total scores ranging from 0 to 21. Higher scores indicate greater anxiety, and a score ≥ 8 is generally considered indicative of clinically relevant symptoms. Functional

outcomes were measured using the FACT–H&N questionnaire. This 39-item instrument includes the core FACT-G domains (physical, social/family, emotional, and functional well-being) along with 12 head-and-neck-specific items addressing speech, swallowing, eating, and cosmetic concerns. Each item is scored on a 0–4 scale, with higher scores indicating better functional status and quality of life. Secondary outcomes included: 1. Adherence to the mindfulness program, assessed through session attendance records and completion of home practice logs. Patients who attended ≥ 6 sessions were considered adherent. 2. Patient satisfaction, evaluated using a single-item 10-point visual analog scale (VAS) administered at the end of the 8-week program. 3. Safety and feasibility, assessed by recording any adverse events or withdrawal due to psychological or logistical reasons. All questionnaires were administered in Mandarin, and patients were supported by trained research assistants to ensure accurate completion. Data collection was standardized across both groups, and assessors were blinded to group allocation where applicable.

2.4. Data collection and follow-up

Data collection was conducted prospectively at three predefined time points: T0, T1, and T2. All participants were assessed using standardized instruments, including the HADS-A and FACT–H&N questionnaires, administered in person at each visit. To ensure consistency, the same trained research assistant facilitated questionnaire completion across all time points. Participants in the intervention group additionally completed weekly attendance checklists and home practice logs, which were collected by the program facilitator. Satisfaction scores were recorded at the final mindfulness session. Any adverse events or study-related issues were documented throughout the intervention period and reviewed by the study team. Follow-up appointments for the T2 assessment were scheduled at the time of radiotherapy completion and reconfirmed via phone reminders. Participants who missed follow-up were contacted up to three times within a 2-week window. The overall follow-up completion rate was 96%, with dropout due to disease progression or relocation. To minimize bias, outcome assessors were blinded to group assignment during data entry and statistical analysis. All collected data were double-checked by two independent reviewers before final inclusion in the analysis dataset. Data were anonymized and stored in a password-protected database with access restricted to study investigators.

2.5. Statistical analysis

All statistical analyses were conducted using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to summarize baseline demographic and clinical characteristics. Continuous variables were expressed as means $\pm$ standard deviations (SD), and categorical variables were presented as frequencies and percentages. Between-group comparisons of continuous variables were performed using independent samples t-tests, while categorical variables were compared using chi-square (χ^2) tests or Fisher's exact test as appropriate. To assess changes over time in anxiety and functional outcomes, a repeated-measures analysis of variance (ANOVA) was conducted with time (T0, T1, T2) as the within-subject factor and group (intervention vs. control) as the between-subject factor. Post hoc pairwise comparisons with Bonferroni correction were applied to detect specific time-

point differences. Pearson correlation analysis was used to examine the association between HADS-A and FACT-H&N scores at follow-up. Partial correlation analyses controlling for age, sex, cancer stage, and baseline functional score were also performed. Adherence rates and satisfaction scores were analyzed descriptively. A two-sided P-value of less than 0.05 was considered statistically significant for all analyses. Missing data were handled using a complete-case analysis approach; no imputation was applied due to low loss to follow-up.

3. Results

3.1. Baseline characteristics

Between January and December 2024, a total of 100 patients with histologically confirmed HNC were prospectively enrolled from the Department of Radiation Oncology at a tertiary cancer center in China. All patients were scheduled to undergo definitive radiotherapy (RT) and were screened according to predefined eligibility criteria, including age between 18 and 75 years, KPS score ≥ 70 , and the ability to participate in structured psychological interventions. Patients with current psychiatric disorders requiring medication, previous mindfulness training, or metastatic disease were excluded. Participants were allocated to either the MBI group ($n = 50$) or a control group receiving standard care ($n = 50$). **Table 1** presents the baseline demographic and clinical characteristics of both groups. No significant differences were observed between groups regarding mean age (MBI: 59.4 ± 7.8 years; Control: 60.1 ± 6.9 years; $P = 0.62$), gender distribution (MBI: 72% male; Control: 70% male; $P = 0.84$), tumor stage (Stage III/IV: MBI 27/23; Control 29/21; $P = 0.72$), and primary tumor site (pharynx, larynx, oral cavity; $P = 0.95$). In addition, both groups showed comparable baseline anxiety levels (HADS-A score: MBI 10.6 ± 2.3 vs. Control 10.4 ± 2.1 ; $P = 0.68$) and functional status (FACT-H&N score: MBI 71.3 ± 6.5 vs. Control 70.9 ± 6.8 ; $P = 0.74$), indicating that the two groups were well matched at study entry and suitable for further comparative analysis.

Table 1. Baseline characteristics.

Characteristic	Intervention group ($n = 50$)	Control group ($n = 50$)	P-value
Age (years)	59.4 ± 7.8	60.1 ± 6.9	0.62
Sex (Male/Female)	36 / 14	35 / 15	0.84
Tumor stage (III/IV)	27 / 23	29 / 21	0.72
Primary site (Pharynx/Larynx/Oral)	21 / 19 / 10	22 / 18 / 10	0.95
HADS-A score (baseline)	10.6 ± 2.3	10.4 ± 2.1	0.68
FACT-H&N score (baseline)	71.3 ± 6.5	70.9 ± 6.8	0.74

3.2. Changes in anxiety levels

Anxiety levels, measured using the HADS-A, were assessed at three time points: T0, T1, and T2. At baseline, both the MBI group and the control group demonstrated comparable anxiety scores (MBI: 10.6 ± 2.3 ; Control: 10.4 ± 2.1 ; $P = 0.68$), indicating no pre-intervention difference. Over time, patients in the MBI group showed a

progressive and statistically significant decrease in anxiety levels. The mean HADS-A score decreased to 8.2 ± 2.1 at T1 and further to 7.4 ± 2.0 at T2. In contrast, the control group demonstrated minimal fluctuation in HADS-A scores, with values of 10.5 ± 2.4 at T1 and 10.2 ± 2.3 at T2, both not significantly different from baseline. Between-group comparisons at both T1 and T2 revealed highly significant differences favoring the MBI group (T1: $P < 0.01$; T2: $P < 0.001$). **Figure 1** visually depicts the temporal trend of HADS-A scores in both groups. The consistent decline in the intervention group supports the effectiveness of the mindfulness-based program in alleviating psychological distress. The results are further detailed in **Table 2**, which presents the mean scores and standard deviations at each time point. These findings suggest that MBIs may significantly reduce anxiety symptoms in HNC patients undergoing radiotherapy, with effects sustained at least three months after treatment completion. The observed reduction exceeds the commonly accepted minimal clinically important difference (MCID) for the HADS-A, supporting its potential clinical relevance in this patient population.

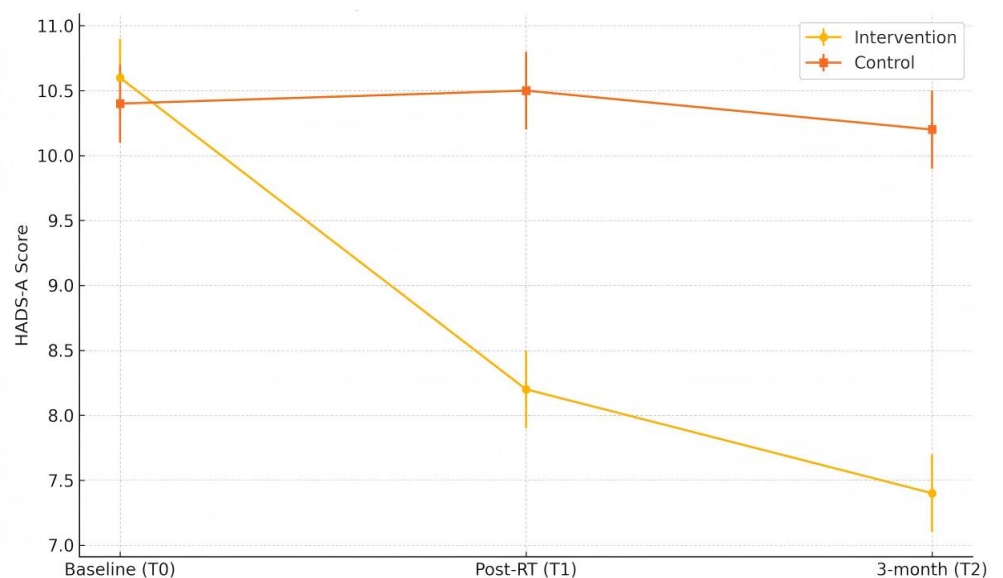


Figure 1. Changes in HADS-A scores over time.

Table 2. Anxiety and functional scores over time.

Timepoint	Group	HADS-A (mean ± SD)
Baseline (T0)	Intervention	10.6 ± 2.3
Post-RT (T1)	Intervention	8.2 ± 2.1
3-month (T2)	Intervention	7.4 ± 2.0
Baseline (T0)	Control	10.4 ± 2.1
Post-RT (T1)	Control	10.5 ± 2.4
3-month (T2)	Control	10.2 ± 2.3

3.3. Functional recovery outcomes

Functional outcomes were assessed using the FACT–H&N questionnaire, which captures patients' quality of life related to HNC symptoms, physical and social

function, and treatment side effects. Measurements were collected at T0, T1, and T2. At baseline, the mean FACT–H&N total score was comparable between the MBI group (71.3 ± 6.5) and the control group (70.9 ± 6.8 ; $P = 0.74$). Over time, patients in the MBI group exhibited a significant improvement in functional scores. By T1, the mean score had increased to 82.3 ± 6.7 , and at T2, it further improved to 88.6 ± 7.2 . In contrast, the control group showed a smaller and non-significant increase in functional status (T1: 75.4 ± 6.2 ; T2: 79.1 ± 6.9). Between-group comparisons at both T1 and T2 demonstrated statistically significant differences favoring the MBI group (T1: $P < 0.01$; T2: $P < 0.001$), indicating that the mindfulness-based intervention may have contributed to enhanced physical, emotional, and social functioning. **Figure 2** illustrates the group-wise differences in FACT–H&N scores across the three time points. The magnitude of improvement observed in the MBI group exceeded the MCID threshold previously established for the FACT–H&N, suggesting the change was not only statistically significant but also clinically meaningful. These findings support the role of mindfulness practices as a complementary approach to functional rehabilitation during and after radiotherapy in HNC patients.

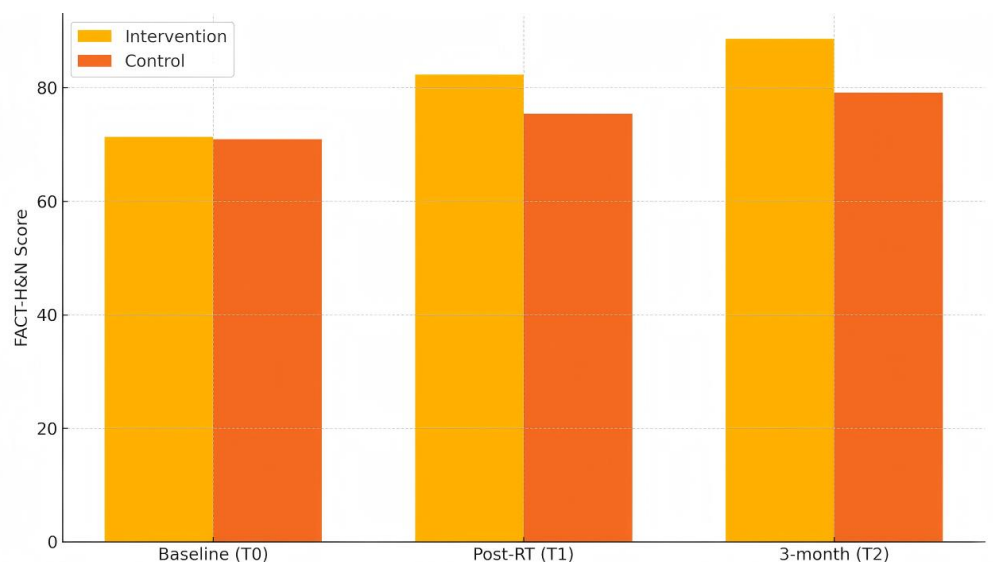


Figure 2. Changes in FACT–H&N scores over time.

3.4. Intervention adherence and patient satisfaction

Adherence to the MBI program was closely monitored to evaluate its feasibility and patient engagement. Of the 50 patients in the intervention group, 42 (84%) completed at least six out of the eight weekly mindfulness sessions, and 38 (76%) attended all eight sessions. Attendance records were maintained by the intervention facilitator, and weekly reminders were sent to all participants. No participants withdrew from the intervention due to psychological discomfort or logistical burden. In addition to in-person attendance, compliance with daily home practice was evaluated using participant-completed logs. Approximately 94% of the patients submitted completed logs for at least five of the eight weeks, with a median self-reported daily practice time of 15–20 min. No adverse events or intervention-related complications were reported during the study period, indicating the safety and

acceptability of the program. Furthermore, patient satisfaction with the intervention was high. Satisfaction scores were collected using a single-item visual analog scale ranging from 1 (not satisfied at all) to 10 (extremely satisfied), administered at the end of the 8-week intervention. The mean satisfaction score was 8.9 ± 0.8 , with over 85% of participants rating the program ≥ 8 . **Figure 3A** depicts the distribution of session attendance across participants, while **Figure 3B** presents the boxplot of satisfaction scores. Detailed adherence and satisfaction data are summarized in **Table 3**. These findings suggest that MBIs are feasible to implement during radiotherapy and are well accepted by HNC patients, even in the context of intensive treatment schedules.

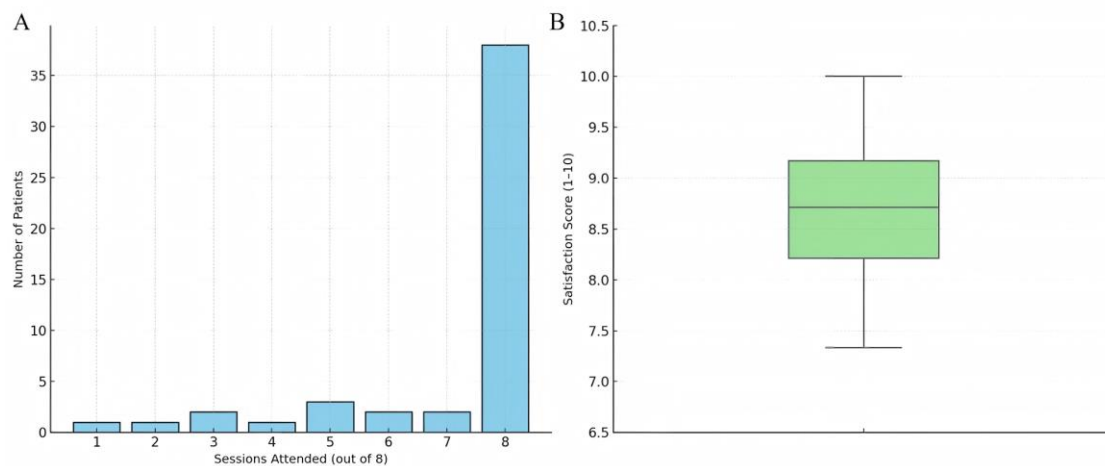


Figure 3. Intervention attendance and satisfaction scores. **(A)** Distribution of session attendance among participants in the MBI group (range: 1 to 8 sessions completed). The majority of patients attended ≥ 6 sessions. **(B)** Boxplot of patient satisfaction scores following the 8-week mindfulness program, based on a visual analog scale (1–10). The median satisfaction score was 9.0, indicating high acceptability of the intervention.

Table 3. Intervention adherence and satisfaction.

Indicator	Result
Average number of sessions attended	6.7 ± 1.4
Completed all 8 sessions (n, %)	38 (76%)
Completed ≥ 6 sessions (n, %)	42 (84%)
Daily practice log completion rate	94%
Mean satisfaction score (1–10)	8.9 ± 0.8
Adverse events reported	None

3.5. Correlation between anxiety and functional status

To further explore the relationship between psychological distress and physical functioning, we examined the correlation between anxiety levels and functional status at T2 using Pearson correlation analysis. This analysis included all participants from both groups who completed assessments at T2 ($n = 96$). A moderate and statistically significant negative correlation was observed between HADS-A scores and FACT-H&N total scores at T2 using Pearson correlation analysis ($r = -0.52$, $P < 0.01$), as illustrated in **Figure 4**. To account for potential confounders, a partial correlation

analysis (also based on Pearson's method) was conducted while controlling for age, gender, cancer stage, and baseline functional score. The negative association remained significant (partial $r = -0.52$, $P < 0.01$), suggesting that anxiety itself may be an independent factor influencing rehabilitation outcomes. The observed relationship underscores the clinical relevance of psychological health in determining the trajectory of cancer recovery. This supports the rationale for integrating structured psychosocial interventions into standard oncologic care, particularly during physically demanding treatments such as radiotherapy. **Figure 4** provides a scatter plot visualization of individual data points, with a regression line indicating the inverse linear association. These results highlight the potential dual benefit of MBIs—both in reducing psychological symptoms and in promoting better functional rehabilitation—reinforcing the biopsychosocial model of cancer care.

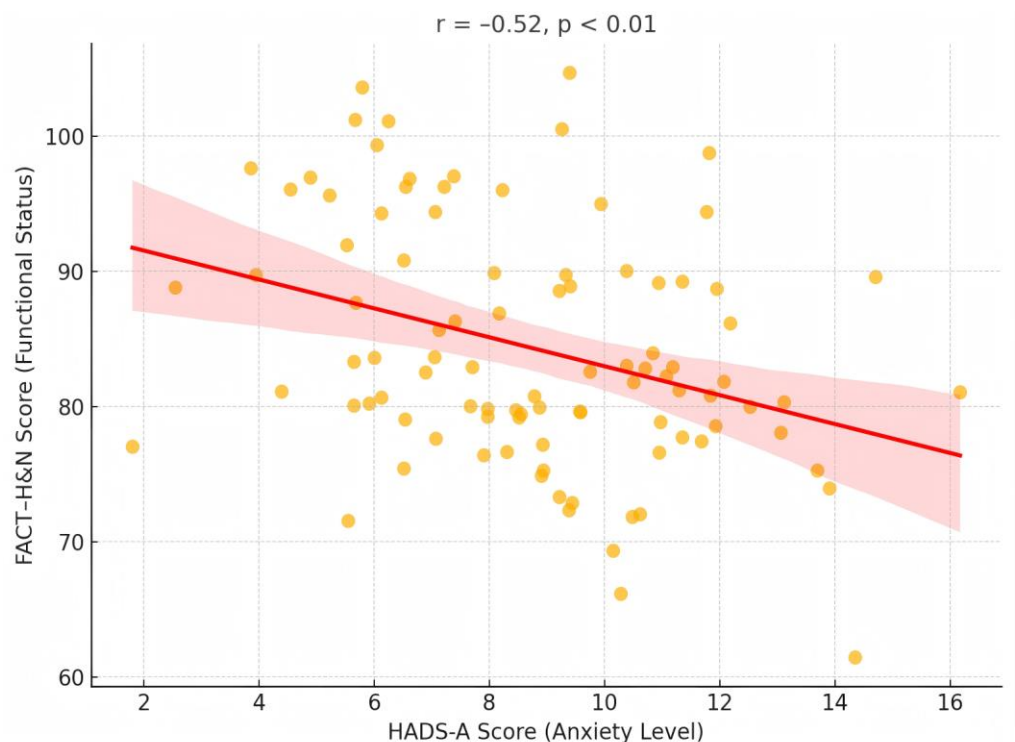


Figure 4. Correlation between anxiety and functional status at follow-up.

4. Discussion

This prospective study provides preliminary but robust evidence supporting the feasibility and efficacy of MBIs in improving both psychological and functional outcomes among HNC patients undergoing radiotherapy. Participants who engaged in an 8-week structured MBI program experienced significantly reduced anxiety and enhanced functional status compared to those receiving standard care alone. These benefits were sustained at 3-month follow-up and accompanied by high adherence, safety, and patient satisfaction. By demonstrating dual-domain improvements, this study addresses a critical gap in psycho-oncologic care for HNC patients and highlights the potential of MBIs to serve as an accessible, low-cost adjunct to conventional cancer rehabilitation. The findings support a broader integrative approach to oncology that prioritizes not only survival, but also psychological

resilience and quality of life. Future randomized, multicenter trials with longer follow-up and mechanistic exploration are warranted to confirm and expand upon these results. Meanwhile, incorporating MBIs into routine supportive care may offer a practical, patient-centered strategy to optimize outcomes during and after cancer treatment.

Furthermore, the demonstrated feasibility, high adherence rate, and strong patient satisfaction observed in this study indicate that MBIs are not only clinically beneficial but also operationally realistic for integration into current supportive care frameworks. Given the minimal infrastructure requirements, flexibility in delivery formats (e.g., group sessions or digital platforms), and low risk profile, MBIs can be promptly adopted as a non-pharmacological adjunct to support emotional and functional well-being during radiotherapy. This is especially relevant in resource-constrained settings or institutions without ready access to formal psychosocial services, where MBIs could fill a critical gap in holistic cancer care.

Although this study employed a non-randomized design, which may introduce inherent limitations such as selection bias, the observed outcomes remain clinically meaningful and provide important insights for future research. Significant improvements were noted in both psychological and functional domains, supporting the feasibility and potential efficacy of MBIs in HNC patients undergoing radiotherapy. Particularly noteworthy is the high adherence and patient satisfaction observed in this high-risk and under-researched population, which underscores the acceptability and practical viability of implementing structured MBIs during active oncologic treatment. These preliminary findings offer a robust foundation for the design of larger-scale, RCTs aimed at validating and expanding upon these early results. Future studies should involve multicenter collaboration, extended follow-up durations, and diverse patient cohorts to improve generalizability and assess the long-term sustainability of benefits.

Additionally, the inclusion of biological correlates—such as cortisol levels, inflammatory cytokines, and neuroimaging assessments—may help elucidate the psychoneuroimmunological mechanisms through which MBIs exert their therapeutic effects. Specifically, MBIs are thought to influence stress-related biological pathways through modulation of the HPA axis, resulting in decreased cortisol reactivity and improved diurnal rhythm stability. Concurrently, mindfulness practice has been shown to downregulate pro-inflammatory cytokines such as IL-6 and TNF- α , which are closely associated with treatment-related fatigue, impaired tissue repair, and psychological distress. On a behavioral level, MBIs enhance emotional regulation, attentional control, and acceptance-based coping strategies, thereby reducing maladaptive rumination and physiological hyperarousal. These psychobiological adaptations may collectively contribute to improved immune surveillance, reduced symptom burden, and accelerated functional recovery during oncologic treatment. Future studies incorporating salivary cortisol assays, cytokine panels, and functional neuroimaging may provide mechanistic insights and help identify potential biomarkers of response to MBIs in patients undergoing radiotherapy for HNC. Collectively, our results provide valuable evidence supporting the integration of MBIs into comprehensive rehabilitation frameworks for HNC patients, and they emphasize

the importance of addressing both psychological resilience and functional recovery in a holistic, patient-centered manner.

5. Conclusion

This prospective controlled study investigated the effects of an 8-week MBI on anxiety and functional outcomes in patients with HNC undergoing radiotherapy. The results provide compelling evidence supporting the efficacy, feasibility, and acceptability of integrating structured mindfulness practices into the clinical care of this population. Compared to the control group receiving standard care, participants in the MBI group demonstrated significantly greater reductions in anxiety symptoms, as measured by the HADS-A. These improvements were not only statistically significant but also exceeded the MCID, underscoring their potential clinical relevance. In addition to psychological benefits, the intervention group showed marked functional improvement, as indicated by increased scores on the FACT-H&N questionnaire at both post-treatment and 3-month follow-up. The magnitude and consistency of the improvements in functional status suggest that mindfulness practices may play a meaningful role in enhancing the physical, emotional, and social recovery of HNC patients undergoing intensive treatment. Furthermore, adherence to the intervention was high, with over 80% of participants completing at least six sessions, and the program was well received, as reflected by high patient satisfaction scores. No adverse events or dropouts related to the intervention were reported, further supporting its safety and feasibility within the context of a busy radiotherapy schedule. These findings align well with the study's original hypothesis that mindfulness training can mitigate treatment-related distress while supporting rehabilitation. By demonstrating improvements in both anxiety and function, this study contributes novel and clinically actionable data to the psycho-oncology literature, particularly within the underexplored context of HNC care. The results underscore the importance of addressing the emotional and functional dimensions of cancer recovery in an integrated manner, and they provide a foundation for broader implementation of MBIs in cancer rehabilitation programs.

The findings of the present study are consistent with and extend those of previous research on MBIs in oncology settings. Numerous studies have demonstrated the psychological benefits of MBIs in patients with breast, prostate, and colorectal cancer, with reductions in anxiety, depression, and cancer-related fatigue being the most frequently reported outcomes [21–25]. For instance, Zhu et al. [26] found that an 8-week MBSR program significantly improved mood and quality of life in breast and prostate cancer survivors, while Naskar et al. [27] reported decreased psychological distress and better coping in patients receiving adjuvant chemotherapy. Meta-analyses have further confirmed the moderate effect size of MBIs on anxiety reduction across various cancer types [28,29]. However, despite the increasing attention MBIs have received in psycho-oncology, relatively few studies have focused on their application in patients with HNC, a population facing unique psychosocial and functional challenges. HNC patients frequently endure disfiguring surgeries, communication impairments, dysphagia, nutritional deficiencies, and social withdrawal, all of which can exacerbate psychological distress [30]. Radiotherapy in this anatomical region

often compounds these issues through mucosal inflammation, altered taste, and xerostomia, further limiting oral intake and speech. As such, the HNC population has a particularly high prevalence of clinically significant anxiety, yet remains underrepresented in studies evaluating structured psychosocial interventions. The present study fills this gap by showing that MBIs can be feasibly delivered during radiotherapy and can confer dual benefits—psychological and functional—in a homogeneous HNC cohort. In contrast to prior studies that often evaluated psychological outcomes alone, our research incorporated a functional endpoint using the FACT–H&N, a disease-specific and clinically meaningful tool [31]. This dual-outcome framework strengthens the relevance of our findings and aligns with current integrative oncology models, which advocate for interventions that simultaneously support emotional well-being and physical rehabilitation. Moreover, previous studies have largely neglected longitudinal follow-up in the HNC context. By demonstrating sustained improvements at 3 months post-treatment, our findings suggest that MBIs may have lasting therapeutic effects that extend beyond the active intervention period. Together, these results position mindfulness as a viable adjunct to standard oncologic care, and they warrant further investigation in more diverse and multicenter HNC populations.

The observed dual benefit of MBIs on both psychological and functional outcomes in HNC patients can be interpreted within the framework of psychoneuroimmunology and behavioral medicine. Mindfulness practices are known to modulate the HPA axis and downregulate the physiological stress response, thereby reducing circulating levels of cortisol and inflammatory cytokines such as IL-6 and TNF- α [32–34]. These biological changes may contribute to improved immune surveillance, better tissue healing, and reduced fatigue—factors that are critical during radiotherapy. At the same time, MBIs help cultivate emotional regulation, cognitive flexibility, and acceptance-based coping, which may buffer the psychological impact of a cancer diagnosis and physically burdensome treatments. Functionally, mindfulness training may enhance body awareness, improve attention to physical cues, and support adaptive behaviors such as maintaining adequate nutrition, voice conservation, and swallowing exercises [35]. Through techniques such as body scanning and breath awareness, patients may also experience greater control over their bodily responses and pain perception, which could contribute to better compliance with rehabilitation protocols. These effects are particularly relevant in HNC, where treatment-related side effects often impair communication, eating, and self-care, and where even modest improvements in function can lead to meaningful gains in quality of life. From a clinical implementation perspective, our findings suggest that MBIs are not only effective but also feasible and well-tolerated within the radiotherapy setting. Unlike conventional psychotherapy, MBIs can be delivered in group formats, require minimal infrastructure, and are adaptable to online or home-based platforms—making them scalable for integration into oncology departments [36]. Furthermore, the high levels of patient satisfaction observed in this study reflect the acceptability and perceived value of the intervention from the patient's perspective. Importantly, the integration of MBIs into cancer care aligns with the World Health Organization's (WHO) vision of holistic and person-centered oncology, which emphasizes mental health, functional preservation, and self-management [37]. The results of this study

highlight the potential of mindfulness to serve not merely as a psychological adjunct, but as a core component of comprehensive cancer rehabilitation for HNC patients.

This study offers several noteworthy strengths that enhance the validity and clinical relevance of its findings. First, it is among the few prospective controlled trials to evaluate the effects of MBIs in a homogeneous cohort of HNC patients undergoing radiotherapy. The use of validated, disease-specific outcome measures—HADS-A for anxiety and FACT-H&N for functional status—allowed for a nuanced and clinically meaningful assessment of intervention efficacy. Second, the dual-focus design addressing both psychological and functional domains represents a novel and comprehensive approach that reflects the multidimensional needs of patients undergoing intensive oncologic treatment. Another strength lies in the pragmatic implementation of the intervention. The mindfulness program was integrated within the real-world clinical workflow, conducted during the radiotherapy period without disrupting routine care. High adherence and satisfaction rates suggest that the intervention was feasible, acceptable, and potentially scalable within similar clinical settings. The inclusion of a 3-month follow-up further adds to the robustness of the findings by demonstrating sustained benefits beyond the immediate treatment phase. However, several limitations must also be acknowledged. First, the study employed a non-randomized design, and group assignment was based on patient availability and willingness to participate in the intervention, which may introduce selection bias. Although baseline characteristics were well matched, unmeasured confounding factors cannot be entirely ruled out. Second, the sample size, while adequate for preliminary analysis, was relatively modest and drawn from a single institution, which may limit generalizability. Additionally, the reliance on self-reported questionnaires, although standardized and validated, introduces the possibility of reporting bias or social desirability effects. The study also did not explore potential biological correlates (e.g., cortisol or cytokine levels) that could help elucidate underlying mechanisms. Finally, long-term outcomes beyond the 3-month follow-up were not assessed, and future studies with extended observation periods are warranted to evaluate durability and delayed effects. Despite these limitations, the current findings provide valuable insight into the potential role of MBIs in the supportive care of HNC patients and lay the foundation for future randomized, multicenter trials.

The findings from this study provide a strong rationale for further investigation into the use of MBIs as a supportive modality in the management of HNC. Future research should aim to build on these results by employing randomized controlled trial (RCT) designs to minimize selection bias and improve the strength of causal inference. Multicenter trials with larger, more diverse patient populations will be essential to enhance generalizability and to examine the intervention's applicability across different health systems and cultural contexts. In addition, future studies should incorporate extended follow-up periods to determine the long-term sustainability of MBI-related benefits. While our 3-month data are encouraging, longer-term outcomes are crucial for understanding whether psychological and functional gains persist or evolve after treatment. Evaluating booster sessions or maintenance-phase mindfulness practices may also inform strategies to sustain benefits over time. Mechanistic research is also needed to clarify the biological and cognitive pathways through which MBIs exert their effects. Integrating biomarkers—such as salivary cortisol, heart rate

variability, and inflammatory cytokines—alongside patient-reported outcomes could provide insights into the psychoneuroimmunological mechanisms underlying observed improvements. Neuroimaging studies may further elucidate how mindfulness influences emotion regulation and attention networks in this uniquely affected population. From a practical standpoint, our findings support the inclusion of MBIs as a complementary component of comprehensive cancer care, particularly in radiation oncology settings. The program’s low cost, minimal resource demands, and high patient acceptability make it well suited for implementation in both urban and resource-limited environments. Digital adaptations—including mobile app delivery or online group sessions—may further enhance scalability and accessibility, especially for patients with mobility challenges or residing in remote areas. In conclusion, MBIs offer a promising, evidence-informed approach to address both psychological distress and functional recovery in HNC patients. Their integration into standard oncologic rehabilitation protocols has the potential to improve patient-centered outcomes and should be prioritized in future psycho-oncology research and policy initiatives.

Author contributions: Conceptualization, XZ and YC; methodology, BL and ZL; software, ZL and YZ; validation, LYL, BZ and XZ; formal analysis, XZ and YC; investigation, BL and ZL; resources, XZ and YC; data curation, BL and ZL; writing—original draft preparation, XZ and YC; writing—review and editing, BL; visualization, LYL; supervision, XZ; project administration, ZL; funding acquisition, XZ. All authors have read and agreed to the published version of the manuscript.

Funding: This project is supported by the General Project of Xinjiang Uygur Autonomous Region Natural Science Foundation (2022D01C297).

Ethical approval: The study took place at the Radiotherapy Department of Guizhou Provincial Tumor Hospital, between January and December 2024. Ethical approval was obtained from the institutional review board (No. GZPTH-KY-20230142).

Informed consent statement: Informed consent was obtained from all subjects involved in the study.

Conflict of interest: The authors declare no conflict of interest.

References

1. Eberly HW, Sciscent BY, Lorenz FJ, et al. Current and Emerging Diagnostic, Prognostic, and Predictive Biomarkers in Head and Neck Cancer. *Biomedicines*. 2024; 12: 415. doi: 10.3390/biomedicines12020415
2. Villafuerte CVL, Ylananb AMD, Wong HVT, et al. Systematic review of intraoperative radiation therapy for head and neck cancer. *Ecancermedicalscience*. 2022; 16: 1488. doi: 10.3332/ecancer.2022.1488
3. Rocha PHP, Reali RM, Decnop M, et al. Adverse radiation therapy effects in the treatment of head and neck tumors. *Radiographics*. 2022; 42: 806–821. doi: 10.1148/rg.210150
4. Forbes E, Clover K, Oultram S, et al. Situational anxiety in head and neck cancer: Rates, patterns and clinical management interventions in a regional cancer setting. *J Med Radiat Sci*. 2024; 71: 100–109. doi: 10.1002/jmrs.736
5. Agarwal SK, Marshall GD Jr. Stress effects on immunity and its application to clinical immunology. *Clinical & Experimental Allergy*. 2001; 31: 25–31. doi: 10.1111/j.1365-2222.2001.01005.x
6. Alqarni AA, Aldhahir AM, Siraj RA, et al. Asthma medication adherence, control, and psychological symptoms: A cross-sectional study. *BMC Pulmonary Medicine*. 2024; 24: 189. doi: 10.1186/s12890-024-02995-x

7. Laradhi AO, Shan Y, Allawy ME. Psychological wellbeing and treatment adherence among cardio-renal syndrome patients in Yemen: A cross section study. *Front Med.* 2024; 11: 1439704. doi: 10.3389/fmed.2024.1439704
8. Riechelmann H, Dejacó D, Steinbichler TB, et al. Functional outcomes in head and neck cancer patients. *Cancers.* 2022; 14: 2135. doi: 10.3390/cancers14092135
9. Kao T-SA, Ling J, Alanazi M, et al. Effects of mindfulness-based interventions on obesogenic eating behaviors: A systematic review and meta-analysis. *Obes Rev.* 2025; 26: e13860. doi: 10.1111/obr.13860
10. Matiz A, Scaggianti B, Conversano C, et al. The effect of mindfulness-based interventions on biomarkers in cancer patients and survivors: A systematic review. *Stress and Health.* 2024; 40: e3375. doi: 10.1002/smi.3375
11. Xu F, Zhang J, Xie S, Li Q. Effects of Mindfulness-Based Cancer Recovery training on anxiety, depression, post-traumatic stress disorder, and cancer-related fatigue in breast neoplasm patients undergoing chemotherapy. *Medicine (Baltimore).* 2024; 103: e38460. doi: 10.1097/MD.00000000000038460
12. Lan X, Xie H, Fu L, Peng W. Effects of mindfulness-based stress reduction on cancer-related fatigue in patients with breast cancer: A meta-analysis of randomized controlled trials. *Frontiers in Oncology.* 2024; 14: 1425563. doi: 10.3389/fonc.2024.1425563
13. Feng Y, Wang K, Fan J, et al. Mindfulness intervention, homogeneous medical concept, and concentrated solution nursing for colorectal cancer patients: A retrospective study. *BMC Cancer.* 2024; 24: 1055. doi: 10.1186/s12885-024-12508-y
14. Xu E, Phung Q, Runcie K, Liu MA. Positive psychology interventions in patients with prostate cancer: A systematic review. *JCO.* 2024; 42: e17005–e17005. doi: 10.1200/JCO.2024.42.16_suppl.e17005
15. Shabani F, Montazeri M, Abdolalipour S, Mirghafourvand M. The effect of mindfulness training on stress and sleep quality of postmenopausal women: A systematic review and meta-analysis. *Post Reprod Health.* 2022; 28: 223–236. doi: 10.1177/20533691221140191
16. Remskar M, Western MJ, Ainsworth B. Mindfulness improves psychological health and supports health behaviour cognitions: Evidence from a pragmatic RCT of a digital mindfulness-based intervention. *British Journal of Health Psychology.* 2024; 29: 1031–1048. doi: 10.1111/bjhp.12745
17. Pan Y, Li F, Liang H, et al. Effectiveness of mindfulness-based stress reduction on mental health and psychological quality of life among university students: A GRADE-assessed systematic review. *Evidence-Based Complementary and Alternative Medicine.* 2024; 2024: 8872685. doi: 10.1155/2024/8872685
18. Guarnaccia JB, Njike VY, Dutton A, et al. A pilot, randomized, placebo-controlled study of mindfulness meditation in treating insomnia in multiple sclerosis. *BMC Neurology.* 2023; 23: 263. doi: 10.1186/s12883-023-03309-0
19. Oliveira AF, Santos IM, Fernandes S, et al. Validation study of the Functional Assessment of Cancer Therapy-Cognitive Function-Version 3 for the Portuguese population. *BMC Psychology.* 2022; 10: 305. doi: 10.1186/s40359-022-01018-w
20. Petrovic M, Salovic B, Tomic A, et al. Functional assessment of cancer therapy – head & neck (FACT-HN) translation and validation in Serbian. *Sci Rep.* 2025; 15: 298. doi: 10.1038/s41598-024-83246-1
21. Zhu P, Liu X, Shang X, et al. Mindfulness-based stress reduction for quality of life, psychological distress, and cognitive emotion regulation strategies in patients with breast cancer under early chemotherapy—A randomized controlled trial. *Holistic Nursing Practice.* 2023; 37: 131. doi: 10.1097/HNP.0000000000000580
22. Victorson D, Mishra KK, Sauer J, et al. Implementation readiness and initial effects of a brief mindfulness audio intervention compared with a brief music control during daily radiation therapy for prostate cancer: A randomized pilot study. *Global Advances in Integrative Medicine and Health.* 2024; 13: 27536130241249140. doi: 10.1177/27536130241249140
23. Chambers SK, Occhipinti S, Foley E, et al. Mindfulness-based cognitive therapy in advanced prostate cancer: A randomized controlled trial. *JCO.* 2017; 35: 291–297. doi: 10.1200/JCO.2016.68.8788
24. Feng Y, Wang K, Fan J, et al. Mindfulness intervention, homogeneous medical concept, and concentrated solution nursing for colorectal cancer patients: a retrospective study. *BMC Cancer.* 2024; 24: 1055. doi: 10.1186/s12885-024-12508-y
25. McCombie A, Jordan J, Mulder R, et al. A randomized controlled trial of mindfulness in recovery from colorectal cancer. *Chin J Integr Med.* 2023; 29: 590–599. doi: 10.1007/s11655-023-3632-1
26. Zhu P, Wu Q, Liu X, et al. Effects of mindfulness-based stress reduction therapy on posttraumatic growth and quality of life in patients with breast cancer under early chemotherapy: A randomized controlled trial. *Holistic Nursing Practice.* 2025; 39: 49. doi: 10.1097/HNP.0000000000000538

27. Naskar S, Dixit S, Varadharasu S, et al. Effect of mindfulness-based intervention on perceived stress among breast cancer patients undergoing chemotherapy. *Journal of Family Medicine and Primary Care*. 2024; 13: 2934. doi: 10.4103/jfmmpc.jfmmpc_1713_23
28. Burgos-Julián FA, Ruiz-Íñiguez R, Peña-Ibáñez F, et al. Mindfulness-based and mindfulness-informed interventions in bipolar disorder: A meta-analysis based on Becker's method. *Clinical Psychology & Psychotherapy*. 2022; 29: 1172–1185. doi: 10.1002/cpp.2717
29. Fulambarkar N, Seo B, Testerman A, et al. Review: Meta-analysis on mindfulness-based interventions for adolescents' stress, depression, and anxiety in school settings: a cautionary tale. *Child and Adolescent Mental Health*. 2023; 28: 307–317. doi: 10.1111/camh.12572
30. Houston H, Beck I, Albert C, et al. Anxiety symptoms predict head and neck cancer survival: Exploring mediation by systemic inflammation and tumor response to treatment. *Psycho-Oncology*. 2024; 33: e6375. doi: 10.1002/pon.6375
31. Petrovic M, Salovic B, Tomic A, et al. Functional assessment of cancer therapy – head & neck (FACT-HN) translation and validation in Serbian. *Sci Rep*. 2025; 15: 298. doi: 10.1038/s41598-024-83246-1
32. Chesnokova V, Melmed S. Minireview: Neuro-immuno-endocrine modulation of the hypothalamic-pituitary-adrenal (HPA) axis by gp130 signaling molecules. *Endocrinology*. 2002; 143: 1571–1574. doi: 10.1210/endo.143.5.8861
33. Walsh E, Eisenlohr-Moul T, Baer R. Brief mindfulness training reduces salivary IL-6 and TNF- α in young women with depressive symptomatology. *Journal of Consulting and Clinical Psychology*. 2016; 84: 887–897. doi: 10.1037/ccp0000122
34. Sanada K, Montero-Marin J, Barceló-Soler A, et al. Effects of mindfulness-based interventions on biomarkers and low-grade inflammation in patients with psychiatric disorders: A meta-analytic review. *International Journal of Molecular Sciences*. 2020; 21: 2484. doi: 10.3390/ijms21072484
35. Solk P, Auster-Gussman LA, Torre E, et al. Effects of mindful physical activity on perceived exercise exertion and other physiological and psychological responses: Results from a within-subjects, counter-balanced study. *Front Psychol*. 2023; 14: 1285315. doi: 10.3389/fpsyg.2023.1285315
36. Wang T, Tang C, Jiang X, et al. Effectiveness of web-based mindfulness-based interventions for patients with cancer: Systematic review and meta-analyses. *Journal of Medical Internet Research*. 2024; 26: e47704. doi: 10.2196/47704
37. Chayadi E, Baes N, Kiropoulos L. The effects of mindfulness-based interventions on symptoms of depression, anxiety, and cancer-related fatigue in oncology patients: A systematic review and meta-analysis. *PLoS One*. 2022; 17(7): e0269519. doi: 10.1371/journal.pone.0269519