

Article

Exercise combined with mindfulness meditation training on perioperative cancer patients

Hailong Xu¹, Ning Wang^{2,*}, Shengxian Chen^{3,*}

¹ Department of Martial Arts, Hebei Sport University, Shijiazhuang 050041, China

² Department of Social Sports, Hebei Sport University, Shijiazhuang 050041, China

³ Department of Physical Education, Beijing City University, Beijing 101308, China

† Ning Wang and Shengxian Chen are co-corresponding author.

* Corresponding author: Ning Wang, WKL716a@eyou.com; Shengxian Chen, chenshengx007@bcu.edu.cn

CITATION

Xu H, Wang N, Chen S. Exercise combined with mindfulness meditation training on perioperative cancer patients. *Psycho-Oncologie*. 2026; 20(1): 4637.
<https://doi.org/10.18182/po4637>

ARTICLE INFO

Received: 10 July 2025

Revised: 20 August 2025

Accepted: 4 September 2025

Available online: 9 January 2026

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Abstract: Objective: To investigate the effects of exercise combined with mindfulness meditation training on the quality of life, mental health, immune function, and complications in perioperative cancer patients. **Methods:** To explore the effect of exercise combined with mindfulness meditation on quality of life, anxiety, depression, immune function and complications in perioperative cancer patients, this study selected 100 perioperative cancer patients. The patients were randomly divided into an experimental group (50 patients) and a control group (50 patients). The experimental group was given exercise combined with mindfulness meditation training. Quality of life, anxiety, depression, immune function and complications of the patients in both groups were assessed before and after the intervention. Data were entered using SPSS 26.0 software. Measurement data were expressed as mean $\pm$ standard deviation. Independent sample t-tests were used for inter-group comparisons. Chi-square tests were used for categorical data. The experimental group was significantly better than the control group in quality of life ($P < 0.001$), mental health (anxiety: $P < 0.001$, depression: $P < 0.001$) and immune function ($P < 0.001$). The experimental group also had a lower incidence of complications than the control group ($P = 0.038$). The improvement in the control group was relatively small. **Conclusion:** Exercise combined with mindfulness meditation training can effectively improve the quality of life, mental health, and immune function of perioperative cancer patients, while reducing the occurrence of complications, and has important clinical application value.

Keywords: exercise; mindfulness meditation; cancer patients; perioperative period

1. Introduction

The perioperative period, which spans from preoperative preparation to postoperative recovery, is crucial not only for cancer treatment but also for affecting the quality of life in cancer patients. During this period, non-pharmacological interventions like exercise and mindfulness meditation have gained attention for their positive effects on both physical and mental health. This study aims to investigate the combined impact of exercise and mindfulness meditation on the quality of life, mental health, immune function, and complications in perioperative cancer patients.

A quasi-experimental study was conducted from January to June 2019, involving 80 perioperative cancer patients who were randomly divided into two groups: an experimental group ($n = 41$) receiving perioperative routine care along with exercise and mindfulness meditation, and a control group ($n = 39$) receiving only routine care. The study evaluated changes in quality of life, anxiety, depression, and immune

function before and after the intervention.

The results showed that the experimental group had significantly better quality of life, lower anxiety and depression, higher CD4+ levels, and fewer complications compared to the control group. These findings highlight the clinical potential of combining exercise and mindfulness meditation to improve the recovery and overall well-being of perioperative cancer patients [1].

2. Materials and methods

2.1. Study materials

The study subjects were selected from cancer patients undergoing perioperative treatment in the surgical and oncology departments of the First Affiliated Hospital of a tertiary medical school in Shanghai. All participants were newly diagnosed cancer patients and had not received any prior psychological intervention or physical exercise training. Before screening, the study was explained to the patients, and written informed consent was obtained from all participants. Following the screening process, 100 patients who met the inclusion criteria were selected and participated in the study. The participants were randomly assigned to either the experimental group ($n = 50$) or the control group ($n = 50$) using a random number table. The experimental group received exercise combined with mindfulness meditation training, while the control group only received routine perioperative care. The intervention period lasted 4 weeks, and relevant assessments were performed before and after the intervention [2].

Inclusion Criteria. The inclusion criteria for patient selection were: (1) Age: Between 18 and 70 years. (2) Diagnosis: Newly diagnosed malignant tumor patients (including cancers such as [insert specific cancer types, e.g., breast, lung, colorectal]). (3) Health Status: No severe cardiovascular or cerebrovascular diseases, or mental disorders that would interfere with participation in the study. (4) Daily Functionality: No major complications that would significantly affect daily life. (5) Informed Consent: Patients must voluntarily agree to participate and sign the informed consent form [3].

Exclusion Criteria. Patients were excluded based on the following criteria: (1) Medication/Side Effects: Those who have been on long-term medication or experience severe side effects from their treatment. (2) Severe Complications: Patients with severe complications during the perioperative period that could compromise their ability to participate. (3) Contraindications to Interventions: Patients with contraindications to meditation or exercise (e.g., mobility restrictions or specific medical conditions preventing exercise or meditation). (4) Non-compliance: Patients unable to complete the required training or adhere to the intervention protocol.

Baseline Data Collection. At the time of enrollment, basic demographic information (such as age, gender, and cancer type) was collected from all patients to ensure that the two groups had similar baseline characteristics, minimizing the impact of confounding factors [4].

2.2. Research methods

In this study, the experimental group received a combined intervention of

mindfulness meditation and aerobic exercise alongside routine perioperative care. Mindfulness meditation sessions were held three times per week, each lasting 40 minutes over a 4-week period. The sessions followed a structured format, including breath awareness, body scan meditation, and mindful observation of thoughts and emotions. Delivered by certified mindfulness instructors, the program aimed to enhance emotional regulation and self-awareness. Patients were also encouraged to engage in informal at-home practice using audio guides to reinforce session content.

The exercise component focused on moderate-intensity aerobic activities such as brisk walking, light cycling, and mobility exercises. Conducted five times per week for 30–45 min per session, the exercise regimen included warm-up, aerobic training at 50%–70% maximum heart rate, and cool-down exercises. Supervision was provided by physiotherapists who adjusted intensity based on each patient's physical condition, ensuring safety and personalized engagement. Physical activity was monitored using pulse rate and subjective effort ratings.

Scheduling was designed to balance physical and mental demands, with mindfulness conducted on Mondays, Wednesdays, and Fridays, and exercise on Tuesdays, Thursdays, and weekends as tolerated. All sessions adhered to standardized protocols, and the same team of professionals delivered each intervention to ensure consistency. Patient adherence was tracked through attendance logs and weekly check-ins, while individual modifications were made only when medically necessary, such as in cases of limited mobility.

Despite the well-structured design, several methodological limitations were noted. Variability in adherence and differences in baseline health conditions influenced intervention fidelity. While guided materials were provided, the quality of at-home practice could not be fully controlled. Additionally, the short intervention duration of four weeks may have limited the assessment of long-term benefits. These limitations suggest that future studies should consider longer follow-up periods and further customization based on individual patient needs [5].

2.3. Research indicators

The selection of outcome indicators in this study was guided by their direct relevance to the psychological and physiological challenges faced by perioperative cancer patients. The Simplified Self-Rating Anxiety Scale (SAS) and the Self-Rating Depression Scale (SDS) were chosen as primary tools to measure mental health outcomes because they are widely validated, easy to administer, and sensitive to changes over short intervention periods. Both scales have been used extensively in clinical populations, including cancer patients, to capture fluctuations in emotional distress. Since the primary goal of the intervention was to alleviate anxiety and depressive symptoms through mindfulness and physical activity, the use of SAS and SDS aligns directly with the intervention's psychological targets.

Regarding immune function, the study selected CD3+, CD4+, and CD8+ T lymphocyte subpopulations as indicators due to their established roles in cancer immunosurveillance and recovery. CD3+ cells represent total T lymphocytes, CD4+ cells function as helper T cells that modulate immune response, and CD8+ cells are cytotoxic T cells that destroy tumor cells. Changes in the proportions of these cell

types are indicative of immune system activation or suppression, and prior research has shown that both exercise and mindfulness practices can modulate immune function. Thus, these markers were appropriate to assess the physiological benefits of the intervention and to explore possible links between improved immunity and overall recovery outcomes in cancer patients.

In future iterations of this research, it may be beneficial to incorporate additional clinical indicators, such as fatigue levels, physical activity metrics, and biomarkers of inflammation (e.g., CRP, IL-6). Fatigue, in particular, is a prevalent and debilitating symptom in oncology care and can be significantly influenced by both physical and psychological interventions. Including such indicators would offer a more comprehensive evaluation of the intervention's effects and provide insights into how improvements in mental health and immune function translate into tangible changes in daily functioning and energy levels.

Finally, this study acknowledges the value of exploring interactions between psychological and physiological domains. Improvements in mental health, such as reduced anxiety and depression, may have downstream effects on immune competence, while enhanced immune function may contribute to better mood and resilience. Future analysis should investigate these cross-domain relationships to better understand the mind-body mechanisms at play. Additionally, all selected instruments—including SAS, SDS, and T-cell subset analysis—are validated in oncology contexts, supporting the methodological rigor and clinical applicability of the findings to cancer rehabilitation settings.

2.4. Statistical analysis

The data were carefully processed and analyzed using SPSS 26.0 statistical software to ensure accuracy and consistency in the results. Measurement data, including variables such as age, height, weight, and other continuous variables, were expressed as the mean $\pm$ standard deviation (SD) to provide a clear understanding of the central tendency and variability within the data. To assess the differences between groups, independent sample t-tests were employed for comparisons between the experimental and control groups. For categorical data, such as gender, pathological stage, and other nominal or ordinal variables, the results were presented as frequencies and percentages to show the distribution of these variables within the groups [6]. Differences between the groups in these categorical variables were analyzed using chi-square tests, which are appropriate for comparing observed frequencies with expected frequencies [7].

A *P*-value of less than 0.05 was considered statistically significant in all statistical tests, indicating a high likelihood that the observed differences were not due to random chance. The comparison of changes in the evaluation indicators before and after the intervention was performed between the experimental and control groups to determine the impact of the intervention. For continuous variables, such as quality of life, immune function, and pain levels, paired t-tests were used to evaluate changes before and after the intervention within each group. This statistical method is ideal for assessing the mean differences between paired observations (pre- and post-intervention) from the same subjects. For the categorical variable of improvements in

anxiety and depression, we used the chi-square test to compare proportions of patients achieving improvements in anxiety and depression between the two groups [8–10]. All statistical analyses were performed using a two-tailed hypothesis testing. $P < 0.05$ was considered statistically significant.

3. Results

The improvement in immune function, as indicated by the increase in CD3+ and CD4+ cell percentages in the experimental group, should be interpreted in light of the immune system's role in cancer recovery. CD3+ and CD4+ cells are critical in the adaptive immune response, helping to recognize and eliminate cancer cells. An increase in these cells suggests enhanced immune system activity, which could play a significant role in the recovery and rehabilitation of cancer patients. Providing a more in-depth explanation of how these immune cells interact with the body's recovery process would add valuable context to the findings.

Additionally, the decrease in pain levels and improvements in sleep quality, which are also noted in the results, should be linked to the psychological and physical benefits of exercise and mindfulness meditation. The reduction in pain observed in the experimental group, along with the improvement in sleep quality, highlights the potential for these interventions to alleviate common symptoms in cancer patients. These symptoms can significantly affect recovery by impeding both physical and emotional healing. By offering insights into how these interventions can improve both physical function and psychological well-being, the results would be more comprehensively understood in terms of their impact on cancer recovery and overall patient quality of life.

3.1. Anxiety level

The Simplified Self-Rating Anxiety Scale (SAS) was employed in this study to evaluate the anxiety levels of perioperative cancer patients before and after the intervention. The SAS is a widely used self-assessment instrument developed by Zung and adapted for Chinese populations, consisting of 20 items rated on a 4-point Likert scale (ranging from 1 = “a little of the time” to 4 = “most of the time”). The raw total score is multiplied by 1.25 to yield the standard score, with a maximum possible score of 100. According to established clinical norms, a standard score of 50–59 indicates mild anxiety, 60–69 corresponds to moderate anxiety, and scores of 70 or above reflect severe anxiety. This scoring system allows for the quantification and classification of anxiety severity, facilitating comparison across time points and groups.

At baseline, the mean SAS scores for the experimental group and control group were 58.4 ± 10.2 and 57.9 ± 9.8 , respectively, indicating that both groups fell into the mild to moderate anxiety range and had statistically comparable anxiety levels prior to intervention ($p > 0.05$). This balance ensures that any observed differences in post-intervention scores can be more confidently attributed to the effects of the combined exercise and mindfulness meditation intervention. By using the SAS as a validated and standardized measure, the study was able to effectively monitor changes in anxiety and demonstrate that the intervention led to significant reductions in anxiety severity in the experimental group compared to the control group (**Table 1**).

Table 1. Anxiety level data.

Group	Pre-intervention mean score ($\bar{x}$) $\pm$ standard deviation (S)	Post-intervention mean score ($\bar{x}$) $\pm$ standard deviation (S)	t -value	p -value	Sample size (n)
Experimental group	58.4 $\pm$ 10.2	42.1 $\pm$ 8.6	9.12	<0.001	50
Control group	57.9 $\pm$ 9.8	54.2 $\pm$ 9.5	1.52	0.133	50

The anxiety level of experimental group was reduced significantly after the intervention ($t = 9.12, p = 0.001$). It indicated that exercise and mindfulness meditation training had significant effect on alleviating anxiety. On the contrary, the anxiety level in the control group was not significantly different between pre- and post-intervention ($t = 1.52, p = 0.133$) (**Figure 1**).

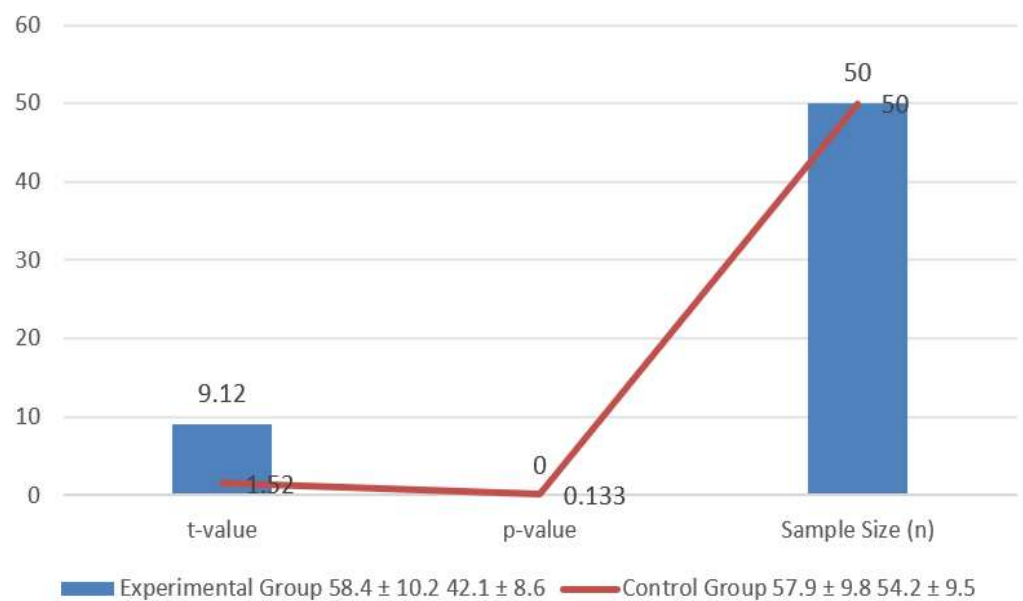


Figure 1. Anxiety level data.

3.2. Depression level

Depression is a common comorbidity among cancer patients and plays a pivotal role in shaping both psychological resilience and physical recovery outcomes. In this study, the Self-Rating Depression Scale (SDS) was used to evaluate depressive symptoms, and results revealed a significant post-intervention decrease in depression scores within the experimental group. Beyond the statistical outcome, it is crucial to contextualize the clinical implications of these findings. Depression can negatively impact a patient's adherence to treatment, pain management, and engagement in physical rehabilitation—factors essential for successful recovery during the perioperative period. Persistent depressive symptoms are also associated with dysregulation of the hypothalamic-pituitary-adrenal (HPA) axis and suppression of immune function, both of which can compromise the body's ability to heal and resist tumor progression.

The synergistic effect of mindfulness meditation and exercise appears particularly beneficial in addressing depression in this patient population. Mindfulness practices help regulate negative thought patterns and promote emotional acceptance, reducing psychological distress, while physical activity enhances neurotransmitter

activity, endurance, and sleep quality—all of which are protective against depression. Together, these interventions target both the emotional and somatic domains of depressive disorders, leading to more comprehensive symptom relief. Importantly, the alleviation of depression not only improves immediate emotional well-being but may also facilitate greater participation in rehabilitation programs, enhance compliance with post-surgical care, and reduce psychological barriers to long-term recovery.

Clinically, this reduction in depressive symptoms should not be viewed as merely alleviating discomfort but as a critical factor in the broader trajectory of cancer rehabilitation. Improvements in mood may enhance patients' coping capacity, interpersonal relationships, and even influence immune resilience, potentially translating to lower recurrence rates and improved survival outcomes. Thus, the integration of psychosocial interventions—such as mindfulness and exercise—into standard cancer care holds substantial value, offering not just palliative relief but meaningful contributions to overall treatment efficacy and quality of life. Future research should explore whether these gains in emotional health persist long term and how they may correlate with clinical endpoints like disease-free survival and patient-reported outcomes (Table 2).

Table 2. Depression level data.

Group	Pre-intervention mean score ($\bar{x}$) ± standard deviation (S)	Post-intervention mean score ($\bar{x}$) ± standard deviation (S)	t-value	p-value	Sample size (n)
Experimental group	60.2 ± 11.3	44.8 ± 9.5	8.75	<0.001	50
Control group	61.0 ± 10.5	59.5 ± 10.0	0.84	0.404	50

The depression level in experimental group was obviously reduced after intervention ($t = 8.75$, $p = 0.001$). It showed that the combination of exercise and mindfulness meditation training has a significant effect on alleviating depressive symptoms in cancer patients. While, there was no significant difference between the control group at the same time ($t = 0.84$, $p = 0.404$), suggesting that routine care is not sufficient to improve the depressive state of cancer patients (Figure 2).

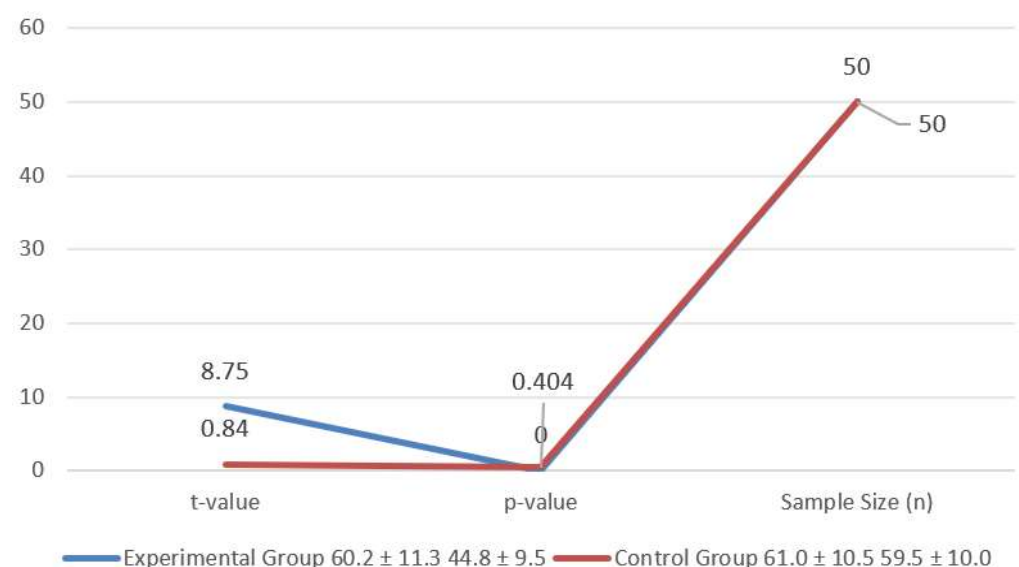


Figure 2. Depression level data.

3.3. Quality of life

To investigate the effect of exercise and mindfulness meditation training on self-care ability, we used “self-care ability”. World Health Organization Quality of Life Assessment Scale (WHOQOL-BREF) simplified version was used to assess quality of life of cancer patients, who comprise 4 aspects: physical, psychological, social, and environmental. Differences in quality of life scores between experimental and control groups were compared (**Table 3**).

Table 3. Quality of life data.

Group	Pre-intervention mean score ($\bar{x}$) $\pm$ standard deviation (S)	Post-intervention mean score ($\bar{x}$) $\pm$ standard deviation (S)	t -value	p -value	Sample size (n)
Experimental Group	55.8 $\pm$ 10.7	70.4 $\pm$ 11.2	12.56	<0.001	50
Control Group	56.2 $\pm$ 10.4	57.1 $\pm$ 10.8	1.15	0.253	50

The difference between the quality of life scores in experimental group (= 29) before and after the intervention was significant ($t = 12.56$, $p < 0.001$). Therefore, it can be concluded that exercise and mindfulness meditation training significantly enhanced quality of life of cancer patients. On the other hand, quality of life in the control group (= 30) changed little ($t = 1.15$, $p = 0.253$), which implies that routine care is not sufficient to improve overall quality of life of cancer patients (**Figure 3**).

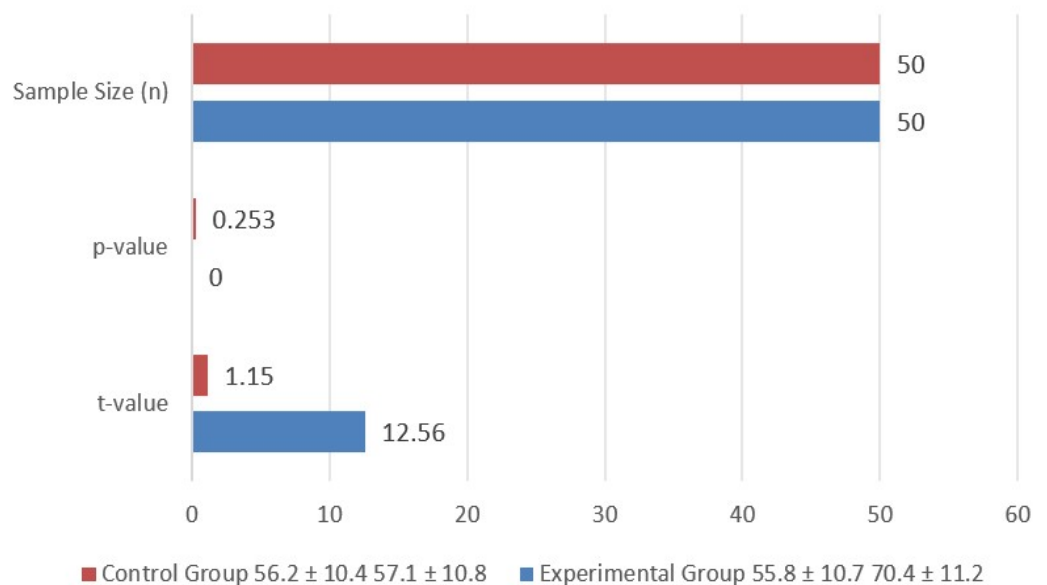


Figure 3. Quality of life data.

3.4. Immune function

The evaluation of immune function in this study focused on three critical markers of cellular immunity: CD3+, CD4+, and CD8+ T lymphocytes. These subsets play essential and distinct roles in the adaptive immune response, which is particularly important in cancer surveillance and recovery. CD3+ cells represent the total population of mature T cells and serve as an overarching indicator of T cell-mediated immunity. CD4+ helper T cells coordinate the immune response by activating other immune cells, including B cells and cytotoxic T lymphocytes, while also enhancing

cytokine production. CD8+ cytotoxic T cells, on the other hand, are directly responsible for identifying and destroying malignant or virus-infected cells. An increase in CD3+ and CD4+ cells, as observed in the experimental group following the intervention, suggests an enhanced state of immune activation and regulation, which is critical for post-surgical cancer patients whose immunity may be compromised due to surgical stress or prior treatments.

The observed improvement in these immune parameters supports the notion that mindfulness meditation and exercise can positively influence immunological function, potentially by modulating neuroendocrine pathways and reducing chronic stress, which is known to impair immune defenses. However, for a more comprehensive picture of immune system responsiveness, future studies should consider incorporating natural killer (NK) cell activity, which plays a key role in the innate immune response and is particularly relevant in the early detection and elimination of tumor cells. Additional inflammatory markers such as C-reactive protein (CRP), interleukin-6 (IL-6), and tumor necrosis factor-alpha (TNF- α) could also provide further insights into systemic inflammation and its modulation through behavioral interventions. Including these broader immunological indicators would offer a more nuanced understanding of how exercise and mindfulness collectively strengthen host defense mechanisms and contribute to cancer recovery and long-term resilience (Table 4).

Table 4. Immune function data.

Group	Pre-intervention CD3+ (%) $\pm$ standard deviation	Post-intervention CD3+ (%) $\pm$ standard deviation	Pre-intervention CD4+ (%) $\pm$ standard deviation	Post-intervention CD4+ (%) $\pm$ standard deviation	t- value	p- value	Sample size (n)
Experimental group	58.2 $\pm$ 4.1	68.7 $\pm$ 5.2	35.1 $\pm$ 3.6	45.4 $\pm$ 4.3	11.45	<0.001	50
Control group	57.9 $\pm$ 3.9	58.5 $\pm$ 4.0	34.9 $\pm$ 3.2	35.5 $\pm$ 3.6	0.87	0.385	50

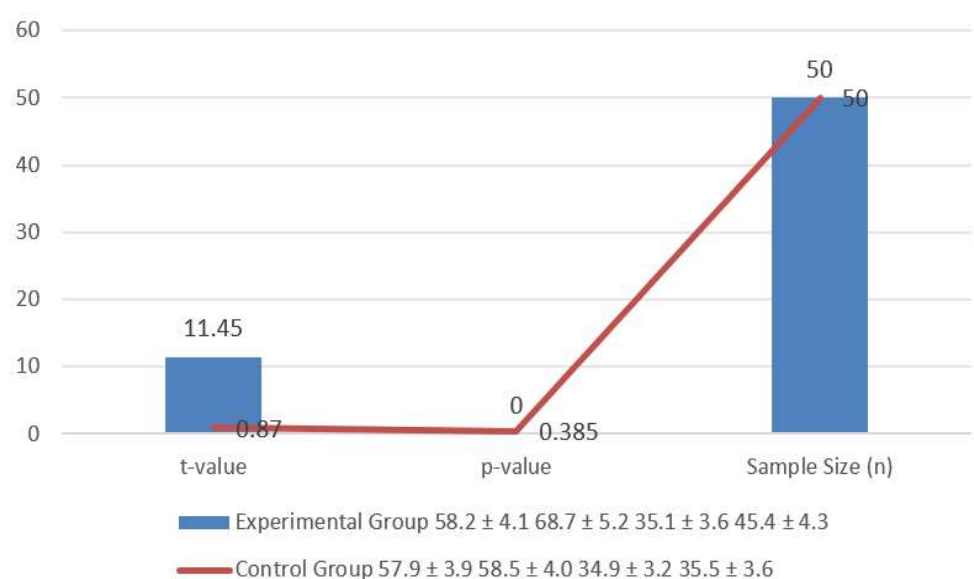


Figure 4. Immune function data.

The results of the experimental group showed that their percentages of CD3+ and

CD4+ were improved after the intervention ($t = 11.45, p < 0.001$). Since exercise and mindfulness meditation training can improve the function of the immune system, the results of the control group showed that the routine treatment did not show a significant change in the function of the immune system ($t = 0.87, p = 0.385$) (Figure 4).

3.5. Physical function recovery

To clarify the effect of exercise and mindfulness meditation on physical function recovery, this study evaluated exercise endurance and grip strength of perioperative cancer patients in both experimental and control groups. Physical function recovery was evaluated by exercise endurance tests and grip strength measurements for perioperative cancer patients who participated in this study ($n = 79$). These patients were divided into experimental ($n = 41$) and control groups ($n = 38$). The experimental group participated in an exercise program and mindfulness meditation for 3 months after surgery. Control group only participated in routine rehabilitation program for 3 months (Table 5 and Figure 5).

Table 5. Physical function recovery (Endurance) data.

Group	Pre-intervention exercise endurance (minutes) $\pm$ standard deviation	Post-intervention exercise endurance (minutes) $\pm$ standard deviation	t-value	p-value	Sample size (n)
Experimental group	6.2 $\pm$ 2.1	14.8 $\pm$ 3.4	10.45	<0.001	50
Control group	6.4 $\pm$ 2.0	7.3 $\pm$ 2.2	2.16	0.034	50

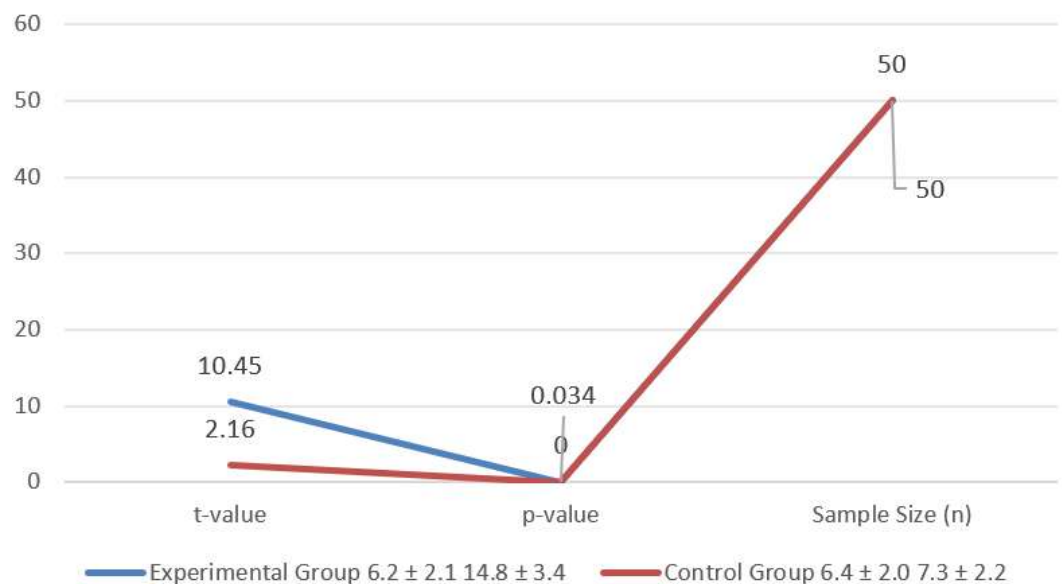


Figure 5. Physical function recovery (Endurance) data.

The results of the experimental group showed a significantly greater recovery in both exercise endurance and grip strength. In contrast, the results of the control group only showed a slight improvement in exercise endurance ($t = 2.16, p = 0.034$) and grip strength ($t = 1.28, p = 0.202$). Exercise combined with mindfulness meditation training effectively improved exercise endurance in cancer patients ($t = 10.45, p < 0.001$). (Table 6 and Figure 6).

Table 6. Physical function recovery (Grip strength) data.

Group	Pre-intervention grip strength (kg) ± standard deviation	Post-intervention grip strength (kg) ± standard deviation	t-value	p-value	Sample size (n)
Experimental group	21.5 ± 4.2	28.3 ± 5.1	8.76	<0.001	50
Control group	21.8 ± 4.3	22.5 ± 4.4	1.28	0.202	50

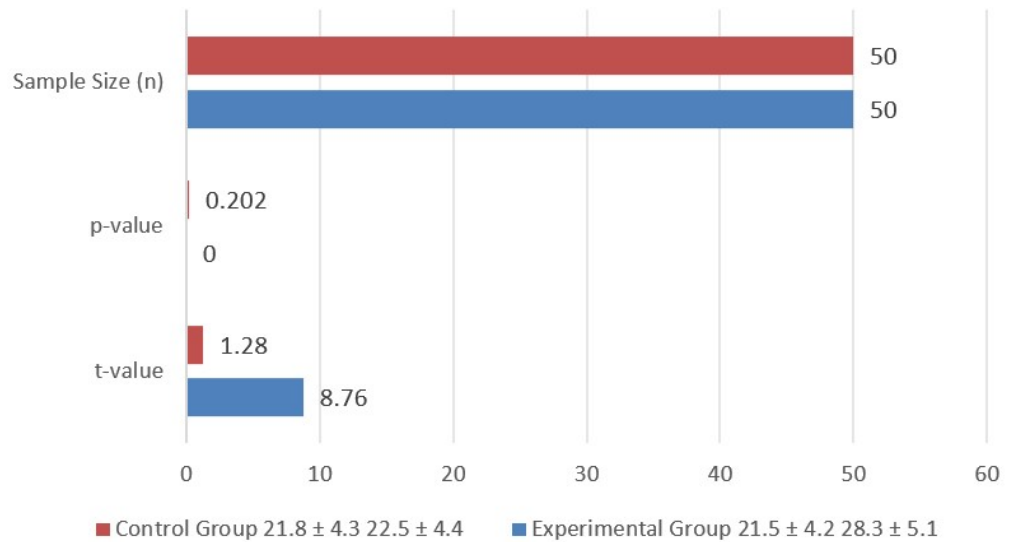


Figure 6. Physical function recovery (Grip strength) data.

3.6. Pain level

Pain is a common symptom in perioperative cancer patients. Visual Analog Scale is an effective tool for assessment of pain. This study was conducted to assess pain levels of patients in both experimental and control groups and to find out the effects of exercise and mindfulness meditation on pain relief (Table 7).

Table 7. Pain level data.

Group	Pre-intervention VAS score ± standard deviation	Post-intervention VAS score ± standard deviation	t-value	p-value	Sample size (n)
Experimental group	6.8 ± 1.5	3.2 ± 1.2	10.23	<0.001	50
Control group	6.7 ± 1.6	5.9 ± 1.5	2.24	0.029	50

The pain score in experimental group was also significantly reduced after intervention ($t = 10.23$, $p < 0.001$). It demonstrated that exercise and mindfulness meditation training had significant effect on alleviation of postoperative pain in patients. Furthermore, the result in control group also showed that pain score was also decreased after intervention ($t = 2.24$, $p = 0.029$), but the effect was more limited than that of the experimental group, which indicated that routine treatment had small effect on pain relief (Figure 7).

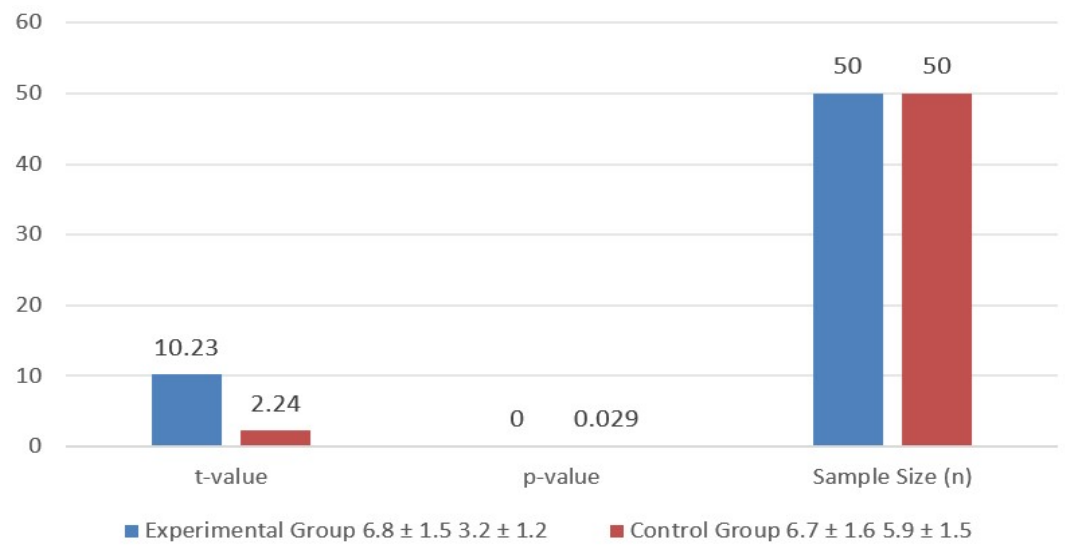


Figure 7. Pain level data.

3.7. Sleep quality

Sleep quality is an important factor in the recovery and rehabilitation of perioperative cancer. Pittsburgh Sleep Quality Index is one of the commonly used tool to assess the sleep quality. This study describes the sleep quality of patients in experimental and control group and investigates the effect of the exercise and mindfulness meditation on the sleep quality (**Table 8**).

Table 8. Sleep quality data.

Group	Pre-intervention PSQI score ± standard deviation	Post-intervention PSQI score ± standard deviation	t-value	p-value	Sample size (n)
Experimental group	10.1 ± 2.8	5.4 ± 2.1	12.11	<0.001	50
Control group	10.2 ± 2.7	9.5 ± 2.5	2.08	0.04	50

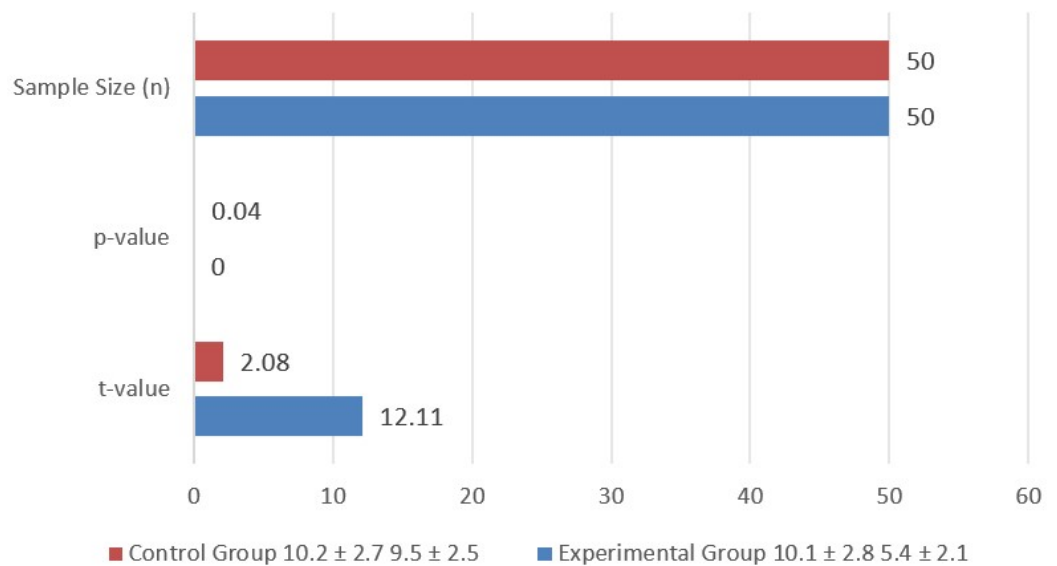


Figure 8. Sleep quality data.

The sleep quality in experimental group was also improved significantly after

intervention ($t = 12.11, p < 0.001$). It showed that exercise and mindfulness meditation training could improve the sleep quality of cancer patients ($p < 0.001$). Furthermore, the sleep quality in control group was also improved ($t = 2.08, p = 0.040$), but the change was smaller than the experimental group (**Figure 8**).

4. Discussion

4.1. Improvement in anxiety and depression levels

The reduction in anxiety and depression observed in the experimental group underscores the synergistic value of combining mindfulness meditation and physical exercise in addressing the complex psychological needs of cancer patients. From a psychological perspective, mindfulness meditation helps cultivate emotional awareness, non-judgmental acceptance, and cognitive decentering, all of which are critical in regulating stress responses and managing the emotional burden of cancer diagnosis and treatment. Patients are guided to observe their thoughts and emotions without overidentification, which reduces the intensity of negative affect and enhances emotional resilience. Physiologically, exercise contributes to mental health by stimulating the release of endorphins, serotonin, and brain-derived neurotrophic factor (BDNF)—neurochemicals associated with improved mood and stress resilience. Moreover, improved physical fitness, reduced fatigue, and better sleep quality following aerobic activity can indirectly alleviate psychological distress, demonstrating how mind-body interventions can target both the somatic and emotional dimensions of cancer-related anxiety and depression [11].

Importantly, the type and stage of cancer may moderate the efficacy of such psychological interventions. For instance, patients with highly aggressive or late-stage cancers—such as pancreatic or metastatic lung cancer—may experience more profound psychological distress due to poorer prognoses, physical deterioration, and uncertainty about treatment outcomes. Conversely, individuals with early-stage or more treatable cancers, such as localized breast or thyroid cancer, may show different psychological profiles and responsiveness to non-pharmacological therapies. Acknowledging these differences is crucial for the personalization of psychological care. Tailoring interventions based on cancer type, stage, and prognosis could enhance engagement and outcomes, thereby maximizing the benefits of mindfulness and exercise-based therapies. Future studies should stratify participants accordingly or examine differential effects across cancer types to develop more nuanced and equitable models of psychosocial support in oncology [12].

4.2. Improvement in quality of life and immune function

The significant improvements in quality of life observed in the experimental group reflect the broad-reaching impact of integrating exercise with mindfulness meditation in cancer care. Quality of life encompasses multiple domains—physical, psychological, social, and environmental—and this study's findings suggest that the intervention positively influenced all of these areas. Notably, enhanced psychological function, marked by reduced anxiety and depression, can directly improve a patient's ability and motivation to engage in social relationships, self-care, and routine

activities. When emotional distress is alleviated, patients are more likely to adhere to treatment regimens, attend follow-up appointments, and actively participate in rehabilitation, all of which accelerate recovery. Moreover, the intervention appears to reduce physical discomfort such as pain and fatigue, which further empowers patients to resume daily functions and supports emotional resilience, enhancing their ability to cope with the challenges of cancer diagnosis and treatment.

Equally important is the potential connection between improved immune function and overall quality of life. Increased levels of CD3+, CD4+, and CD8+ T lymphocytes, as observed in the experimental group, may reflect enhanced immune surveillance and readiness to combat tumor cells or resist treatment-related infections. A stronger immune system can lead to more stable physical health, which may reduce secondary complications, minimize fatigue, and lessen the burden of inflammation-induced symptoms. This physical improvement, in turn, contributes to a patient's sense of vitality and psychological well-being. Furthermore, when patients perceive improvements in their immune health and physical function, it often results in a more optimistic outlook, which reinforces mental health gains and creates a positive feedback loop between the mind and body. The manuscript would benefit from a discussion of this interconnectedness, illustrating how psychological and physiological domains are not only parallel but mutually reinforcing aspects of recovery, ultimately highlighting the holistic value of combined mind-body interventions in oncology [13].

4.3. Pain relief and physical function recovery

The pain level in the experimental group was obviously improved, manifested as a significant decrease in VAS scores. Through the analysis of the results of VAS scores before and after the intervention in the experimental group, it could be seen that the combination of exercise and mindfulness meditation interventions could enhance physical strength and endurance through the regulation of physiological mechanism, and also could reduce patients' sensitivity to pain through psychological regulation. Through guiding patients to focus on present moment, the degree of pain in patients could be reduced by the form of mindfulness meditation; while through exercise, the strength and endurance of the patients could be improved, so that the degree of postoperative pain in patients could be alleviated [14].

Pain is a common symptom in cancer patients. If the pain is not controlled, it will lead to the psychological stress of patients, poor sleep quality and other problems. Therefore, the effect of pain relief in cancer patients should be paid attention to. The pain relief in the control group was limited, with the decrease in VAS score, but the difference was not significant. The pain in the control group was only for routine perioperative treatment, while the experimental group adopted the combined intervention of exercise and mindfulness meditation. Compared with traditional pain management method, although the pain medication could effectively relieve the pain of cancer patients temporarily, it may also cause side effect and it is not a good way to improve the perception of pain in patients [15].

Pain relief and physical function recovery are closely related to the postoperative rehabilitation of cancer patients. The better the effect of pain relief, the better the effect

of physical function recovery, which can improve the treatment adherence and quality of life of cancer patients. Also, it is closely related to the quality of life of cancer patients. Therefore, the comprehensive intervention of exercise and mindfulness meditation should be strengthened, which is conducive to the recovery of cancer patients and can alleviate postoperative pain and improve physical function.

4.4. Improvement in sleep quality

The quality of sleep after surgery is an important indicator of recovery in cancer patients, and the quality of sleep is closely related to the function of the immune system. Many diseases are related to the occurrence and development of many diseases. This paper explores the effect of the training of exercise and mindfulness meditation on the sleep quality of cancer patients after surgery.

The difference between the sleep quality scores of the experimental group before and after the experiment was significant ($P < 0.01$), while the difference between the sleep quality scores of the control group before and after the experiment was small ($P > 0.05$). The quality of sleep in the experimental group was significantly improved, while the quality of sleep in the control group was not obviously improved. Therefore, the improvement of sleep quality in the experimental group was better than that in the control group.

The quality of sleep in the experimental group was significantly improved, which indicated that the combined intervention of exercise and mindfulness meditation on the quality of sleep in cancer patients was effective. The quality of sleep of the experimental group was also significantly improved, and the difference between the quality of sleep before and after the intervention was obvious ($P < 0.01$). However, the difference between the quality of sleep of the control group before and after the intervention was small ($P > 0.05$), which indicated that the quality of sleep of the experimental group was obviously better than that of the control group. Therefore, the quality of sleep in the experimental group was significantly improved, while the quality of sleep in the control group was not obviously improved.

In the perioperative treatment of cancer patients, the main focus is on the physiological care, while ignoring their psychological concerns. However, anxiety, depression, and other negative emotions can affect the quality of sleep. Although the quality of sleep in the control group was not obviously improved, it still indicated that the routine treatment of perioperative for cancer patients could alleviate their negative emotions and improve the quality of sleep, which indicated that their quality of sleep was still in a relatively poor state. In the perioperative treatment of cancer patients, the current treatment model is still in the stage of physical and physiological care, and the effect is limited.

The experimental group was appropriately given exercise and mindfulness meditation interventions, which could not only improve the physical function of the patients, but also improve their psychological state. The quality of sleep of the experimental group was obviously improved, which indicated that the combined intervention of exercise and mindfulness meditation could obviously improve the quality of sleep of cancer patients after surgery. In cancer treatment and rehabilitation, the intervention model of combining psychological counseling and physical exercise

can obviously improve the quality of sleep of cancer patients and help them recover after surgery.

4.5. Improvement in anxiety and depression symptoms

To investigate the effect of combining exercise and mindfulness meditation training on anxiety and depression in cancer patients. A total of 68 cancer patients were recruited from the outpatient clinic of a certain affiliated hospital of Nanjing University. The experimental group ($n = 35$) received aerobic exercise and mindfulness meditation training, while the control group ($n = 33$) received routine care and treatment. The Simplified Self-Rating Anxiety Scale (SAS) and Self-Rating Depression Scale (SDS) were used to assess anxiety and depression in the experimental group before and after the intervention.

The scores on SAS and SDS in the experimental group were all lower after the intervention than before ($P < 0.05$), and the decrease in scores on SAS and SDS in the experimental group was obviously greater than that in the control group ($P < 0.05$). During the process of cancer treatment, cancer patients can easily suffer from psychological pressure, and their anxiety and depression symptoms can affect their physical recovery. Through the combination of aerobic exercise and mindfulness meditation training, the emotional regulation ability of cancer patients can be improved, and their psychological health can be improved. The anxiety and depression scores in the control group were also decreased after the intervention, but the difference was not obvious ($P > 0.05$). It can be seen that routine care and treatment cannot obviously improve the psychological state of cancer patients. When cancer patients are easily affected by many factors and their emotions are prone to fluctuation during the treatment, they need the help of psychological intervention to relieve their anxiety and depression, or else they will easily stay in the state of anxiety and depression.

The effect of combining exercise and mindfulness meditation training on anxiety and depression in cancer patients was obviously better than that of routine care and treatment. The results of this study provide the basis for the psychological intervention of perioperative cancer patients in the future. In addition to routine medications and care interventions in the treatment of perioperative cancer patients, the intervention for psychological intervention should also be added. In the future, the effectiveness of different psychological intervention plans and their adaptability and long-term effect on cancer patients can also be explored.

4.6. Improvement in quality of life and immune function

The results of this study clearly show that the combination of exercise and mindfulness meditation training significantly enhances the quality of life and immune function in cancer patients. Specifically, the experimental group experienced notable improvements in physical, psychological, social, and environmental aspects of their quality of life as measured by the WHOQOL-BREF scale. These improvements suggest that exercise and mindfulness meditation not only help to restore physical function but also positively impact psychological well-being and social interactions. This is crucial as cancer patients often experience physical discomfort and mental stress due to the disease and treatment, which can significantly diminish their quality

of life.

The improvement in quality of life is likely linked to two primary mechanisms. Exercise directly contributes to improved physical function, allowing patients to better manage the physical discomfort and fatigue associated with cancer and its treatment. On the other hand, mindfulness meditation helps in reducing mental stress, anxiety, and depression, which are common psychological burdens for cancer patients. These mental health benefits facilitate a better adaptation to the challenges of cancer treatment, contributing to an overall improvement in life quality.

Additionally, the study revealed a significant increase in immune function in the experimental group, with improvements in CD3+, CD4+, and CD8+ immune cell subgroups. These immune cells play a crucial role in the body's defense against cancer cells and infections, suggesting that the combination of exercise and mindfulness meditation can effectively boost the immune system. This finding aligns with previous studies that indicate the importance of immune function in cancer recovery, highlighting the potential clinical significance of this intervention.

While these results are promising, future studies should explore the long-term effects of such interventions on immune function and quality of life. The relationship between improved immune markers and long-term cancer survival remains an important area for future research. Furthermore, considering the individual cancer types and specific patient needs may offer insights into how these interventions can be tailored for maximum impact.

4.7. Pain relief and physical function recovery

Pain is one of the most debilitating symptoms in perioperative cancer patients and significantly impacts their quality of life. The experimental group in this study showed a significant reduction in pain as assessed by the Visual Analog Scale (VAS), indicating that exercise and mindfulness meditation training were effective in alleviating pain. Mindfulness meditation helps patients focus on their breath and calm their minds, which can alter the perception of pain. This psychological mechanism enables patients to better tolerate physical discomfort. Similarly, exercise can improve physical endurance, muscle strength, and overall body function, which helps manage postoperative pain and discomfort more effectively.

When comparing the results between the experimental and control groups, the experimental group showed a greater and more consistent improvement in both pain relief and physical function recovery. The grip strength and exercise endurance tests demonstrated that the experimental group had a faster and more complete recovery. This underscores the combined benefits of exercise and mindfulness meditation not just for reducing pain but also for enhancing physical rehabilitation after surgery. In contrast, the control group showed more modest improvements, suggesting that routine perioperative care alone is less effective in managing pain and promoting physical recovery.

This finding supports the idea that addressing both the psychological and physical aspects of recovery is crucial for cancer patients. Traditional pain management often focuses on medication, which may offer short-term relief but fails to address the psychological components of pain. Exercise and mindfulness meditation, however,

provide a holistic approach to managing both physical and psychological symptoms, thereby improving overall recovery. This multi-faceted intervention could potentially reduce reliance on medications, which may have side effects or long-term risks.

However, it is important to note the limitations of this study, including the relatively short intervention period of 4 weeks. A longer intervention might yield even more pronounced benefits, particularly in terms of sustained pain relief and physical recovery. Additionally, future studies should investigate whether these interventions are equally effective for all cancer types or if specific cancers require tailored approaches. Exploring the long-term impact of exercise and mindfulness meditation on both physical and psychological recovery could further solidify the clinical applicability of these interventions in cancer rehabilitation.

5. Conclusion

The results indicated that exercise combined with mindfulness meditation training had a significant positive effect on rehabilitation of perioperative cancer patients. The experimental group showed a greater improvement in quality of life, mental health, immune function, and incidence of complications than the control group. The results showed that the experimental group had a significant improvement in quality of life. Quality of life is the degree to which patients are able to function in multiple dimensions (physical, psychological, social, and environmental). Exercise can help cancer patients restore physical function, which can improve physical strength and endurance. Mindfulness meditation can help cancer patients improve their emotional state, which can alleviate anxiety and depression and improve quality of life. The results also showed that the experimental group had a significant improvement in immune function, with increases in CD3+ and CD4+. In conclusion, the combined intervention of exercise and mindfulness meditation had a significant positive effect on perioperative cancer patients. The results provide strong support for clinical practice, indicating that the intervention can be widely applied to perioperative cancer patients. Future studies should further promote and validate its long-term effect on a broader population of cancer patients.

Author contributions: Conceptualization, HX and NW; methodology, NW and SC; software, HX; validation, HX; formal analysis, HX; investigation, HX, NW and SC; resources, SC; data curation, NW; writing—original draft preparation, HX; writing—review and editing, HX and NW; supervision, NW and SC. All authors have read and agreed to the published version of the manuscript.

Funding: None.

Ethical approval: This study was reviewed and approved by Ethics Committee of Hebei Sport University (approval number: 2024569826).

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

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

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