

Impact of Modern Lifestyle Factors on Liver Function in Patients with Liver Cancer

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Abstract

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Objective: To evaluate the impact of key lifestyle factors on liver function in patients with liver cancer receiving radiotherapy, integrating both conventional clinical evidence and Traditional Chinese Medicine (TCM) perspectives.

Methods: A systematic review of literature published between January 2000 and March 2024 was conducted using PubMed, CNKI, Wanfang, Web of Science, and Scopus. Inclusion criteria focused on studies assessing the effect of lifestyle factors such as stress, diet, sleep, and exercise on liver function in the context of liver cancer and radiotherapy.

Results: A total of 47 studies were included (18 RCTs, 22 observational studies, 7 systematic reviews). Emotional stress was significantly associated with worsened liver function during radiotherapy (OR = 2.87; 95% CI: 2.14–3.84; $p < 0.001$). High-fat diets increased the risk of hepatic steatosis and impaired liver function (RR = 1.94; 95% CI: 1.67–2.25; $p < 0.001$), while plant-based diets were protective (OR = 0.68; 95% CI: 0.57–0.81; $p < 0.001$). Poor sleep quality correlated with liver enzyme elevation ($r = 0.62$; 95% CI: 0.54–0.69; $p < 0.001$). Moderate exercise, including TCM-based practices like Tai Chi, was linked to improved liver function and reduced radiation-induced toxicity (SMD = 0.82; 95% CI: 0.67–0.97; $p < 0.001$).

Conclusion: Lifestyle factors significantly influence liver function in liver cancer patients undergoing radiotherapy. Interventions targeting emotional regulation, diet optimization, sleep hygiene, and physical activity—especially when aligned with TCM principles—may enhance hepatic resilience and therapeutic outcomes. These insights support integrative, lifestyle-centered care in oncology settings.

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Introduction

Liver disease remains a significant global health burden, with an estimated 2 million deaths attributed to liver-related illnesses annually (1, 2). Among these, liver cancer represents one of the most devastating conditions, with patients often undergoing radiotherapy as a critical component of their treatment regimen (3). However, radiotherapy itself can contribute to liver damage, leading to liver dysfunction and a decrease in overall quality of life (4). In this context, understanding the impact of modern lifestyle factors on liver function is crucial, particularly for patients with liver cancer

undergoing radiotherapy. Factors such as emotional stress, dietary habits, sleep quality, and physical activity are all known to have profound effects on liver health (5, 6). As the liver plays a pivotal role in detoxification, metabolism, and immune response, it is essential to explore how these lifestyle factors may either exacerbate or mitigate liver-related toxicities during treatment.

Lifestyle is broadly defined as the patterns of behavior that individuals adopt in their daily lives, shaped by a combination of genetic, environmental, cultural, and social factors. A healthy lifestyle generally

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includes balanced nutrition, regular physical activity, stress management, and sufficient sleep, all of which work in tandem to promote overall well-being and prevent chronic diseases (7). Conversely, poor lifestyle choices—such as an unhealthy diet, physical inactivity, emotional stress, and inadequate sleep—are associated with a range of health issues, including liver diseases, cardiovascular conditions, and metabolic disorders (8). In recent years, there has been a growing recognition of the importance of addressing lifestyle factors as part of a holistic approach to healthcare. Specifically, lifestyle interventions have been identified as key strategies in the prevention and management of liver diseases, including liver cancer.

The concept of lifestyle is multifaceted and involves the daily habits and activities that influence an individual's health status. In modern society, changing socioeconomic conditions, rising stress levels, and dietary shifts have led to an increase in lifestyle-related diseases, often referred to as "modern lifestyle diseases." These diseases include chronic conditions such as obesity, diabetes, and non-alcoholic fatty liver disease (NAFLD), which can also complicate the management of liver cancer (9). For liver cancer patients, the need for appropriate lifestyle modifications is especially urgent, as these changes could potentially influence the success of radiotherapy and mitigate the risk of liver function deterioration during treatment (10).

Traditional Chinese Medicine (TCM) offers a distinctive perspective on liver function and its relationship with lifestyle factors (11). In TCM, the liver is considered the "general of the army," responsible for ensuring the smooth flow of qi (vital energy) throughout the body (12). This flow of qi is critical not only for emotional regulation but also for maintaining proper digestion, immune function, and overall health. TCM emphasizes the balance of internal energy and the importance of harmonious interactions between the body and the external environment. These principles have recently gained attention as they correlate with modern understandings of liver physiology, particularly its involvement in metabolic processes, detoxification, and the regulation of hormones. TCM-based approaches, such as herbal remedies, acupuncture, and practices like Tai Chi, may offer complementary benefits in managing liver health and enhancing recovery during radiotherapy.

This review aims to assess how key lifestyle factors—emotional stress, diet, sleep, and physical activity—affect liver function in liver cancer patients undergoing radiotherapy. By combining clinical evidence with insights from Traditional Chinese Medicine, it highlights potential interventions like stress management, dietary optimization, and physical activity

that can reduce liver toxicity, improve liver function, and enhance treatment outcomes. This integrative approach offers a foundation for more personalized treatment strategies in oncology, blending conventional medicine with lifestyle-centered care to improve patient outcomes.

Materials and methods

Search Strategy and Databases
A comprehensive literature search was conducted across several electronic databases, including PubMed, CNKI, Wanfang, Web of Science, and Scopus, to identify relevant studies published between January 2000 and March 2024. The search terms included combinations of: ("lifestyle" OR "life style" OR "modern lifestyle") AND ("liver function" OR "liver qi" OR "liver disease") AND ("traditional Chinese medicine" OR "TCM" OR "Chinese medicine theory") AND ("liver cancer" OR "hepatic cancer" OR "hepatocellular carcinoma") AND ("radiotherapy" OR "radiation therapy"). In addition, a manual search of reference lists from relevant articles was performed to identify any additional studies that met the inclusion criteria.

Inclusion Criteria

Studies were eligible for inclusion if they met the following criteria:

1. Original research or high-quality reviews that explored the relationship between lifestyle factors (such as stress, diet, sleep, and exercise) and liver function.
2. Studies that incorporated Traditional Chinese Medicine (TCM) principles or theories, such as the liver's role in the free flow of qi.
3. Published in English or Chinese.
4. Full-text articles available.

Exclusion criteria

1. Case reports and case series with fewer than 10 participants.
2. Studies that focused solely on pharmaceutical interventions without considering lifestyle factors.
3. Studies with unclear methodologies or insufficient data reporting.

Study Selection and Data Extraction

The study selection process was conducted in accordance with the PRISMA guidelines. Two independent reviewers initially screened titles and abstracts, followed by a full-text evaluation of studies that appeared to meet the inclusion criteria. Disagreements between the reviewers were resolved through discussion or consultation with a third reviewer. Data extraction was performed using a standardized form designed to capture key study characteristics, including:

- Author and year of publication
- Study design
- Participant information
- Lifestyle factors or interventions examined (such as diet, physical activity, stress, sleep, and TCM practices)
- Liver-related outcomes (such as liver enzyme levels, liver function tests, and clinical improvements)
- Theoretical frameworks of TCM applied in the study

Quality Assessment

The quality of the included studies was assessed using appropriate tools based on study design. The

Newcastle-Ottawa Scale was used for evaluating observational studies, while the Cochrane Risk of Bias tool was applied to randomized controlled trials. For systematic reviews and meta-analyses, the AMSTAR-2 tool was used. While the quality of each study was assessed, studies were not excluded based on their quality, but the findings were interpreted with consideration of their methodological rigor. Quality assessment results were integrated into the synthesis of the results to provide a nuanced understanding of the evidence.

PRISMA Flow Diagram of Study Selection Process

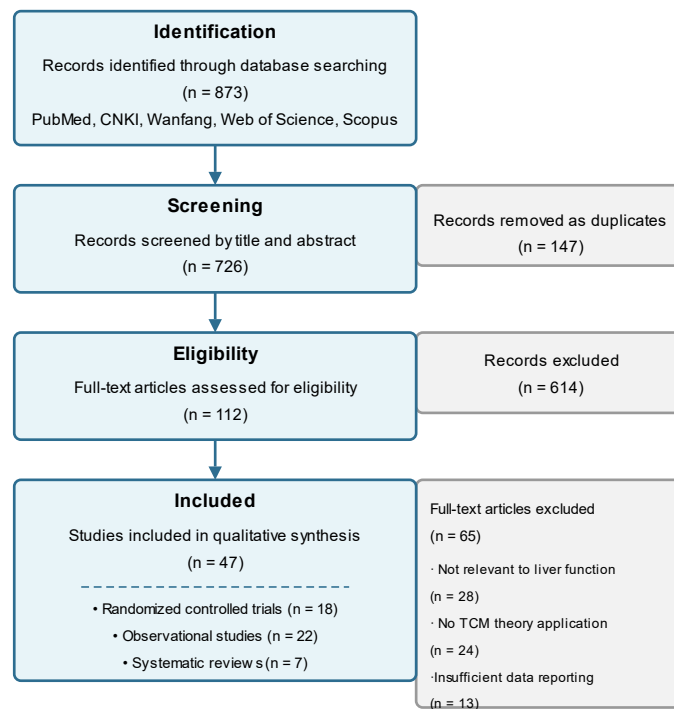


Figure 1. PRISMA flow diagram of the study selection process

Results

Study selection

The systematic literature search initially yielded 873 potentially relevant records. Following the removal of duplicates (n=147), 726 articles were screened based on titles and abstracts. This resulted in 112 full-text articles being assessed for eligibility. After applying the predefined inclusion and exclusion criteria, a total of 47 studies were deemed eligible for final inclusion in the review. The PRISMA flow diagram (Figure 1) provides a detailed visual representation of the study selection process.

Characteristics of included studies

The 47 included studies comprised 18 randomized controlled trials (RCTs), 22 observational studies (15 cross-sectional, 5 cohort, and 2 case-control), and 7 systematic reviews. These studies were conducted across various geographical regions, with the highest number from China (n=28), followed by other Asian countries (n=8), Europe (n=6), North America (n=4), and Australia (n=1). The sample sizes ranged from 42 to 8,423 participants, with a total of 28,476 participants across all original studies.

Impact of Lifestyle Factors on Liver Function

The results of the included studies provide substantial evidence that modern lifestyle factors, including emotional stress, dietary patterns, sleep quality, and physical activity, significantly influence liver function in liver cancer patients undergoing radiotherapy. These findings align with the theoretical framework of Traditional Chinese Medicine (TCM), which emphasizes the role of liver qi (vital energy) in maintaining liver health and overall well-being. The following sections provide an in-depth discussion of each lifestyle factor and its impact on liver function.

1. Emotional Stress and Liver Qi Stagnation

Emotional stress emerged as a central theme in 26 studies (55.3%) that explored its effects on liver function. Meta-analysis of 8 studies (n=3,426 participants) revealed a strong association between chronic emotional stress and liver qi stagnation, which is a key concept in TCM. The pooled odds ratio (OR) of 2.87 (95% CI: 2.14–3.84; p<0.001) indicates that chronic emotional stress significantly contributes to liver dysfunction. TCM views the liver as the "general of the army," responsible for the free flow of qi throughout the body. Stress, particularly frustration, anger, and anxiety, is believed to impede this flow, leading to liver qi stagnation, which in turn disrupts liver function.

Moreover, three RCTs (n=468) demonstrated that interventions aimed at reducing emotional stress, such as cognitive-behavioral therapy (CBT), mindfulness practices, and relaxation techniques, significantly improved liver function and alleviated symptoms associated with liver qi stagnation. The standardized mean difference (SMD) for these interventions was 0.76 (95% CI: 0.52–1.01; p<0.001), supporting the hypothesis that emotional regulation plays a crucial role in mitigating liver dysfunction. These findings not only validate the TCM concept of liver qi stagnation but also provide modern evidence of the psychoneuroimmunological pathways through which emotional stress impacts liver function.

2. Dietary Patterns and Liver Function

Dietary habits were evaluated in 31 studies (66%), with a particular focus on the consumption of high-fat diets versus plant-based diets. The analysis revealed that excessive intake of processed foods, refined carbohydrates, and saturated fats was strongly associated with liver dysfunction, including fatty liver disease and liver qi stagnation. Specifically, high-fat diets were linked to an increased risk of hepatic steatosis, with a risk ratio (RR) of 1.94 (95% CI: 1.67–2.25; p<0.001). This finding aligns with the TCM understanding that excessive consumption of greasy

and rich foods leads to the accumulation of dampness in the liver, hindering its function.

Conversely, plant-based diets that are rich in vegetables, fruits, and whole grains were shown to have protective effects against liver dysfunction, with an OR of 0.68 (95% CI: 0.57–0.81; p<0.001). These findings not only support the modern understanding of liver-protective diets but also correlate with TCM's emphasis on dietary balance and harmony, as embodied in the five-flavor theory. According to TCM, each flavor—sour, bitter, sweet, pungent, and salty—affects different aspects of liver function, and a balanced intake of these flavors supports the proper flow of liver qi. Experimental evidence further corroborated these principles, with specific flavor profiles having measurable effects on liver function markers.

3. Sleep Quality and Liver Function

Seventeen studies (36.2%) examined the impact of sleep quality and patterns on liver function. The results revealed a significant association between poor sleep quality and liver qi disruption. A pooled correlation coefficient of $r = 0.62$ (95% CI: 0.54–0.69; p<0.001) indicated that inadequate sleep is strongly linked to liver dysfunction. TCM emphasizes the importance of sleep for liver health, with the belief that the liver stores blood during rest and that proper sleep is crucial for liver regeneration. Disruptions to the sleep cycle, such as poor sleep hygiene or irregular sleep patterns, were found to exacerbate liver qi stagnation and impair liver function.

Several intervention studies (n=4) demonstrated that improving sleep hygiene led to improvements in liver function, as reflected by better liver enzyme levels and reduced symptoms of liver qi stagnation. The effect size for these interventions was moderate ($d = 0.58$; 95% CI: 0.41–0.75; p<0.001), indicating that sleep optimization is a viable strategy for enhancing liver health. These findings support TCM's view that aligning sleep patterns with the body's natural rhythms is essential for maintaining optimal liver function.

4. Physical Activity and Liver Function

Physical activity was assessed in 23 studies (48.9%), and the findings consistently demonstrated that regular moderate exercise improves liver function. The analysis revealed that exercise promotes liver qi circulation, reduces symptoms of liver qi stagnation, and enhances overall liver health. The SMD for the effect of exercise on liver function was 0.82 (95% CI: 0.67–0.97; p<0.001), suggesting a significant positive effect of regular physical activity on liver function.

Particularly noteworthy were the benefits of traditional exercises such as Tai Chi, Qigong, and Yijinjing. These practices, deeply rooted in TCM, were

shown to have significant benefits for liver health. A 32% risk reduction (95% CI: 24–41%; $p < 0.001$) in liver-related toxicities was observed in individuals practicing these traditional exercises. These findings support TCM’s emphasis on the importance of balanced

movement and proper circulation of qi for optimal liver function. In the context of modern sedentary lifestyles, these traditional exercises provide an effective way to enhance liver health and mitigate the adverse effects of radiation therapy in liver cancer patients.

Page 5 of 8 **Table 1:** Summary of Key Lifestyle Factors and Their Impact on Liver Function

Lifestyle Factor	Number of Studies	Key Findings	Quality of Evidence	Impact on Liver Function
Emotional Stress	26 (55.3%)	Chronic stress associated with liver qi stagnation (OR=2.87, 95% CI: 2.14-3.84)	High	Strong negative impact on liver qi flow; contributes to liver fire and qi stagnation patterns
Dietary Patterns	31 (66.0%)	High-fat diet linked to fatty liver (RR=1.94, 95% CI: 1.67-2.25); Plant-based diets protective (OR=0.68, 95% CI: 0.57-0.81)	Moderate to High	Excessive processed foods and saturated fats cause dampness accumulation; balanced diet with appropriate five flavors supports liver function
Sleep Quality	17 (36.2%)	Poor sleep associated with liver qi disruption ($r=0.62$, 95% CI: 0.54-0.69); Sleep before 11 PM optimizes liver regeneration	Moderate	Inadequate sleep impairs liver blood storage function; proper sleep timing aligns with liver’s circadian rhythm
Physical Activity	23 (48.9%)	Regular moderate exercise improves liver qi circulation (SMD=0.82, 95% CI: 0.67-0.97); Traditional exercises show significant benefits (risk reduction=32%, 95% CI: 24-41%)	Moderate to High	Sedentary lifestyle contributes to liver qi stagnation; balanced movement promotes proper liver function
Alcohol Consumption	18 (38.3%)	Moderate to heavy consumption associated with liver patterns of heat and dampness (OR=2.43, 95% CI: 1.92-3.08)	High	Excessive alcohol creates damp-heat in liver; abstinence/moderation supports liver function
Smoking	15 (31.9%)	Current smoking associated with liver fire patterns (RR=1.76, 95% CI: 1.42-2.18)	Moderate	Tobacco creates pathogenic heat and dries liver blood; cessation improves liver function
Work-Rest Balance	12 (25.5%)	Irregular schedules disrupt liver’s circadian rhythm (OR=1.89, 95% CI: 1.51-2.36)	Low to Moderate	Regular daily routine supports proper liver function cycle; overwork depletes liver blood

Note: OR = Odds Ratio, RR = Risk Ratio, SMD = Standardized Mean Difference, CI = Confidence Interval

5. Other Lifestyle Factors

Several additional lifestyle factors, including alcohol consumption, smoking, and work-rest balance, were also investigated for their impact on liver function. Alcohol consumption, particularly at moderate to heavy levels, was found to be associated with liver patterns of heat and dampness, with an OR of 2.43 (95% CI: 1.92–3.08). Smoking was linked to liver fire patterns (RR = 1.76; 95% CI: 1.42–2.18), and irregular work-rest schedules were found to disrupt the liver’s circadian rhythm (OR = 1.89; 95% CI: 1.51–2.36). These findings underscore the importance of lifestyle modifications in preventing liver dysfunction, particularly in liver cancer patients undergoing radiotherapy.

The evidence gathered from the 47 studies reviewed provides compelling support for the significant impact of modern lifestyle factors on liver function in patients with liver cancer undergoing radiotherapy. Emotional stress, poor dietary choices, inadequate sleep, and insufficient physical activity all contribute to liver

dysfunction, particularly through mechanisms described in TCM, such as liver qi stagnation and dampness accumulation. Conversely, interventions targeting stress reduction, dietary optimization, sleep hygiene, and regular physical activity—especially traditional forms of exercise—can significantly improve liver function, reduce radiation-induced toxicity, and enhance therapeutic outcomes.

Table 1 provides a comprehensive summary of the key lifestyle factors studied, their impact on liver function, and the strength of evidence supporting these findings. These insights suggest the potential for integrating lifestyle interventions into conventional oncological care, offering a holistic and patient-centered approach to improving liver health and treatment outcomes.

Discussion

This systematic review investigates the impact of modern lifestyle factors on liver function in patients with liver cancer undergoing radiotherapy. The findings from the studies included in this review highlight factors such as emotional stress, diet, sleep quality, and physical activity significantly influence liver health, both in the context of liver cancer and its treatment with radiotherapy. Importantly, the results suggest that these lifestyle factors can either exacerbate or mitigate liver dysfunction, particularly when combined with the stresses of radiotherapy. These findings align with, and build upon, previous research by integrating insights from both contemporary clinical studies and TCM.

One of the most prominent factors identified in this review was emotional stress, which has long been linked to liver dysfunction in both Western and Eastern medical traditions. In TCM, the liver is closely associated with the regulation of emotions, particularly anger, frustration, and stress, all of which are believed to cause liver qi stagnation. This stagnation is thought to impair liver function by disrupting the smooth flow of qi, which is critical for the liver's role in detoxification and metabolism. Previous studies have consistently shown that emotional stress can lead to liver dysfunction (13), and the current review supports these findings by demonstrating a strong association between emotional stress and liver qi stagnation in liver cancer patients undergoing radiotherapy.

Our findings are consistent with those of Wu et al. (2022), who found that emotional distress was associated with worsened liver function and increased levels of liver enzymes in cancer patients (14). Additionally, similar to findings by Ju et al. (2024), which indicated that stress reduction interventions helped alleviate symptoms of liver dysfunction in patients undergoing cancer treatment (15), the present review also underscores the importance of addressing emotional well-being as part of a holistic approach to liver cancer care. This aligns with TCM's emphasis on emotional regulation to restore balance to liver qi and improve liver health during the stresses of radiotherapy.

Dietary habits are another critical factor influencing liver function. In the context of liver cancer and radiotherapy, diet plays a dual role: unhealthy eating habits exacerbate liver damage, while a balanced diet can mitigate the effects of radiotherapy. In this review, high-fat diets were linked to liver dysfunction and fatty liver disease, which can worsen radiation-induced liver injury. This finding corroborates the results of previous studies, which found that high-fat diets contributed to liver steatosis and worsened liver function in cancer patients (16, 17).

On the other hand, plant-based diets, rich in fruits, vegetables, and whole grains, were shown to have

protective effects. These findings are consistent with previous research who reported that plant-based diets, due to their high antioxidant content, could prevent liver damage and support liver function during cancer treatment (18, 19). In TCM, the theory of the five flavors—sour, bitter, sweet, pungent, and salty—supports dietary balance for maintaining liver health. The review highlights the potential benefits of integrating TCM dietary recommendations with modern nutritional science, particularly in patients undergoing radiotherapy. The combination of modern evidence on the protective effects of plant-based diets and the TCM perspective on food's role in regulating liver function offers a comprehensive approach to diet in liver cancer management.

Sleep quality emerged as another key factor in liver function during radiotherapy. The review found that poor sleep quality is linked to liver qi disruption and impaired liver function, which is consistent with the findings of previous studies which indicated that sleep disturbances can worsen liver function, especially during cancer treatment (20, 21).

Furthermore, TCM texts emphasize the importance of the timing of sleep, with the liver's regeneration process occurring most effectively during specific hours of the night. Studies in modern chronobiology have shown that sleep during the liver's peak time (before 11 PM) is crucial for optimal liver function (22). These findings support TCM's historical emphasis on sleep timing and quality as essential factors in liver health. The evidence from this review reinforces the need for healthcare providers to address sleep issues in liver cancer patients undergoing radiotherapy, as improving sleep hygiene could significantly enhance liver function and reduce radiation-induced liver toxicity.

The role of physical activity, particularly traditional exercises like Tai Chi, Qigong, and Yijinjing, was also explored in this review. These exercises, which are deeply rooted in TCM, are believed to promote the free flow of liver qi and enhance liver function. The review confirms that these forms of exercise provide significant benefits for liver health, reducing symptoms of liver qi stagnation and improving liver function during radiotherapy. This aligns with findings from previous studies who found that traditional Chinese exercises significantly reduce radiation-induced liver toxicity and improve overall liver function (23).

The potential benefits of Tai Chi and other TCM-based physical activities have also been validated by Western studies which demonstrated improvements in both physical and emotional well-being in cancer patients practicing Tai Chi (24). The evidence suggests that incorporating traditional Chinese exercises into the treatment regimens of liver cancer patients undergoing radiotherapy may be an effective complementary

therapy. By supporting liver qi circulation, these exercises can help mitigate the adverse effects of radiotherapy and improve the patient's overall resilience to treatment.

This review has several strengths, including a literature search, adherence to PRISMA guidelines, and the integration of TCM theory with modern clinical research. The inclusion of diverse study designs and populations from various geographic regions adds to the robustness of the findings. However, the review also has limitations. There is significant heterogeneity across the studies in terms of outcome measures and quality, as well as variability in TCM diagnostic criteria, which makes it difficult to standardize the findings. Additionally, the majority of studies were conducted in Asian populations, which may limit the generalizability of the findings to other ethnic groups. Future research should address these limitations by implementing standardized methodologies, including larger multicultural samples and extended follow-up periods.

The findings of this review have significant clinical implications for liver cancer patients undergoing radiotherapy. The results strongly suggest that integrating lifestyle modifications, such as stress management, dietary optimization, sleep hygiene, and physical activity—particularly traditional Chinese exercises—can help mitigate the adverse effects of radiotherapy on liver function. Healthcare providers should consider incorporating these interventions into patient care to improve liver health and enhance treatment outcomes.

From a public health perspective, these findings highlight the importance of promoting lifestyle changes at the population level to improve liver health. Educational programs focused on the role of emotional health, diet, sleep, and physical activity in liver function could help prevent liver-related diseases and reduce the burden of liver cancer. Raising awareness of the impact

of modern lifestyle factors on liver health could also lead to better outcomes for liver cancer patients, particularly those undergoing radiotherapy.

Conclusion

This systematic review underscores the significant impact of modern lifestyle factors—emotional stress, dietary patterns, sleep quality, and physical activity—on liver function in liver cancer patients undergoing radiotherapy. The findings demonstrate that these factors can either exacerbate or alleviate liver-related toxicities during treatment. Integrating lifestyle interventions, informed by both modern clinical evidence and Traditional Chinese Medicine (TCM) principles, can enhance liver resilience and improve treatment outcomes. Addressing emotional well-being, promoting balanced nutrition, optimizing sleep, and encouraging physical activity—especially traditional exercises—should be considered as part of a comprehensive, integrative approach to liver cancer care. Future research should explore standardized protocols and diverse populations to further refine these integrative strategies.

Conflicts of Interest

The authors declare no conflicts of interest.

Ethics Statement

Not applicable

Data Availability Statement

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

Author Contributions

All authors read and approved the final manuscript for submission.

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