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(REVIEW ARTICLE)

Evaluate the effect of Tai Chi Chuan in lung cancer survivors by using the biomarkers

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Abstract

The rising prevalence of non-small cell lung cancer (NSCLC) necessitates innovative rehabilitation strategies to enhance the quality of life for survivors. This essay explores the potential of Tai Chi Chuan (TCC), a traditional Chinese exercise known for its slow, deliberate movements and mindfulness practices, as an effective intervention for cancer rehabilitation. Through a systematic literature review, we investigate the impact of TCC on various biomarkers associated with inflammation, oxidative stress, and immune function, alongside its effects on health-related quality of life (HRQOL). Evidence suggests that TCC can significantly reduce levels of pro-inflammatory cytokines, such as interleukin-6 (IL-6) and tumor necrosis factor-alpha (TNF-α), while enhancing antioxidant enzyme activity, thereby mitigating treatment-related side effects and promoting recovery. Furthermore, TCC has shown promise in improving physical functioning, reducing cancer-related fatigue, and enhancing psychological well-being among survivors. By fostering social interactions within group settings, TCC also addresses feelings of isolation prevalent among cancer survivors. Despite the encouraging findings, the essay highlights the need for more rigorous randomized controlled trials to further elucidate the mechanisms underlying TCC's benefits. Ultimately, this review underscores the importance of integrating holistic approaches like TCC into cancer care, paving the way for personalized rehabilitation strategies that address the complex needs of NSCLC survivors. The findings contribute to a growing body of evidence advocating for non-pharmacological interventions in cancer rehabilitation, emphasizing the interplay between physical activity, psychological health, and biological markers as vital components of effective recovery pathways.

Keywords: Non-Small-Cell Lung Cancer Survivor; Tai Chi Chuan; Biomarker; Health-Related Quality of Life; Rehabilitation

1. Introduction

The prevalence of cancer continues to rise globally, with non-small cell lung cancer (NSCLC) being one of the most common and lethal forms. NSCLC includes various types of epithelial lung cancer, primarily squamous cell carcinoma, large cell carcinoma, and adenocarcinoma. The management of NSCLC often involves aggressive treatment regimens, including surgery, chemotherapy, and radiation therapy, which can lead to significant physical and psychological distress in survivors (Xu *et al*., 2019). As a result, there is a pressing need for effective rehabilitation strategies that not only alleviate physical symptoms but also enhance overall well-being.

In this review, Tai Chi Chuan (TCC), a traditional Chinese exercise characterized by slow, deliberate movements and deep breathing, has emerged as a promising intervention for cancer survivors, particularly those recovering from NSCLC. TCC has been shown to improve various health outcomes in cancer patients, including physical functioning, quality of life, and psychological well-being (Jiang *et al*., 2023; Xu *et al*., 2019). The mechanisms through which TCC exerts these effects are multifaceted and may involve the modulation of biological markers associated with inflammation, oxidative stress, and immune function (Xu *et al*., 2019). Identifying and assessing these biomarkers can

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provide valuable insights into the efficacy of TCC as a rehabilitation tool for NSCLC survivors. Biomarkers are biological indicators that can reflect physiological states, disease progression, and treatment responses. In the context of cancer rehabilitation, the biomarkers could serve as crucial tools for evaluating the impact of interventions like TCC on cellular and systemic health (Xu *et al*., 2019). For instance, the KEAP1-NRF2 pathway is integral to antioxidant responses and inflammation regulation, which are particularly relevant in the context of cancer recovery (Jiang *et al*., 2023). Increased levels of NRF2 and associated antioxidant markers have been linked to improved health outcomes in cancer patients, suggesting that TCC may enhance these pathways, thereby facilitating recovery. Research indicates that TCC can significantly impact immune function by increasing the activity of immune cells and modulating inflammatory cytokines (Xu *et al*., 2019). For example, studies have demonstrated that TCC can elevate the levels of interleukin-10 (IL-10), an anti-inflammatory cytokine, while reducing pro-inflammatory markers like tumour necrosis factor-alpha (TNF-α) (Jiang *et al*., 2023). This shift in cytokine profiles is critical for cancer survivors, as chronic inflammation is associated with cancer progression and recurrence. Furthermore, the improvement in immune function through TCC may help mitigate treatment-related side effects, enhancing the overall quality of life for NSCLC survivors.

Tai Chi Chuan's impact on fatigue—a common and debilitating symptom among cancer survivors—is also noteworthy. A meta-analysis showed that TCC significantly reduces cancer-related fatigue (CRF), particularly in breast and lung cancer patients (Song *et al*., 2023). This finding underscores the potential of TCC as a non-pharmacological intervention to improve fatigue and overall functionality in cancer survivors. As fatigue can severely limit daily activities and diminish quality of life, incorporating TCC into rehabilitation programs could offer significant benefits. In addition to physical and psychological improvements, TCC may facilitate recovery by enhancing biomarkers related to bone health, which is particularly important for cancer survivors who may experience treatment-induced bone loss (Xu *et al*., 2019). Research indicates that TCC may help maintain bone mineral density and reduce the risk of fractures, thereby addressing one of the significant long-term complications faced by cancer survivors. This aspect of TCC is especially relevant for NSCLC patients, many of whom may undergo treatments that compromise bone integrity.

Despite the promising evidence supporting the benefits of TCC for cancer survivors, more rigorous studies are needed to establish a comprehensive understanding of its mechanisms and efficacy, particularly concerning biomarker modulation. Current literature suggests a need for randomized controlled trials that not only assess clinical outcomes but also examine the underlying biological changes resulting from TCC interventions (Song *et al*., 2023; Jiang *et al*., 2023). By utilizing biomarkers to evaluate the rehabilitation effects of TCC, researchers can gain deeper insights into how this traditional practice influences recovery pathways and ultimately improves health outcomes in NSCLC survivors. Application of biomarkers to evaluate the rehabilitation of Tai Chi Chuan in cancer survivors, particularly those with non-small cell lung cancer, offers a novel approach to understanding and enhancing recovery. With an estimated 234,580 new cases of lung cancer in the United States in 2024, and a 5-year relative survival rate varying significantly by stage, focusing on rehabilitation strategies like TCC is crucial (American Cancer Society, 2024). By focusing on the interplay between TCC and biological indicators of health, future research can elucidate the specific pathways through which TCC exerts its beneficial effects, paving the way for more effective rehabilitation strategies tailored to the needs of cancer survivors. As the landscape of cancer care continues to evolve, integrating traditional practices like TCC into modern rehabilitation programs may provide a holistic approach to improving the quality of life for NSCLC survivors.

2. Methodology

This methodology outlines a comprehensive approach to evaluating the application of biomarkers in assessing the rehabilitation effects of Tai Chi Chuan (TCC) in cancer survivors, with a specific focus on non-small cell lung cancer (NSCLC). By synthesizing findings from existing literature, this review aims to explore how TCC influences biomarkers related to inflammation, oxidative stress, and overall health outcomes in cancer survivors.

The literature review would begin with a thorough search across multiple databases, including PubMed, Web of Science, Cochrane Library, and relevant Chinese databases. The objective is to identify randomized controlled trials (RCTs) and systematic reviews that assess the effects of TCC on cancer survivors, particularly focusing on studies that measure biomarkers associated with health outcomes. Inclusion criteria could target studies involving adult participants diagnosed with NSCLC or other cancer types, provided they offer relevant insights into the impact of TCC on biomarkers and rehabilitation (Xu *et al*., 2019). To ensure a comprehensive understanding of the current state of research, the literature review should encompass both qualitative and quantitative studies. Qualitative studies would provide valuable context and insights into the lived experiences of cancer survivors participating in TCC, capturing the psychological and emotional benefits associated with this practice. Quantitative studies, on the other hand, could deliver statistical data on the effects of TCC on various biomarkers and health outcomes, thereby offering measurable evidence of its effectiveness (Jiang *et al*., 2023). The key biomarkers to be evaluated in the literature would include antioxidant

markers such as superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GPx), which are critical for assessing the body's ability to counteract oxidative stress. Additionally, inflammatory cytokines such as interleukin-6 (IL-6), tumour necrosis factor-alpha (TNF-α), and interleukin-10 (IL-10) could be examined to understand how TCC influences the inflammatory response in cancer survivors (Song *et al*., 2023). Furthermore, the role of the KEAP1-NRF2 signaling pathway could be explored, as it is essential for regulating antioxidant responses and maintaining cellular health, particularly in the context of cancer recovery (Xu *et al*., 2019).

The data extraction process could involve systematically reviewing the relevant findings from each identified study, categorizing them based on the types of biomarkers measured, the effects of TCC on these biomarkers, and the overall health outcomes reported. This synthesis facilitates the identification of patterns and trends within the literature, ultimately providing a clearer understanding of how TCC may enhance recovery and rehabilitation in NSCLC survivors (Xu *et al*., 2019). To synthesizing findings, the methodology should include a critical appraisal of the quality of the included studies. This assessment would consider various factors, including study design, sample size, and the robustness of the biomarkers measured. By evaluating the methodological rigor of the studies, the review would highlight areas of strength as well as potential limitations in the existing body of research on TCC and biomarkers in cancer rehabilitation (Song *et al*., 2023).

Ethical considerations should also be addressed, acknowledging that while direct ethical oversight may not apply to this literature review, all studies included would have undergone appropriate ethical scrutiny by their respective institutional review boards. This ensures that the research findings synthesized in this review are derived from ethically conducted studies, thereby reinforcing the credibility and reliability of the conclusions drawn (Jiang *et al*., 2023).

The methodology outlines a structured literature review approach to evaluate the application of biomarkers in assessing the rehabilitation effects of Tai Chi Chuan in cancer survivors, particularly those with non-small cell lung cancer. By systematically synthesizing existing research, this review aims to provide valuable insights into the effectiveness of TCC in enhancing recovery and improving health outcomes for cancer survivors. Through careful analysis of biomarkers and health-related quality of life, the review would establish a framework for understanding the potential benefits of integrating TCC into rehabilitation programs for cancer patients, thereby contributing to the ongoing discourse on holistic approaches to cancer care (Xu *et al*., 2019).

The comprehensive exploration of TCC's effects on biomarkers can pave the way for future research and clinical applications, potentially leading to improved rehabilitation strategies that optimize the recovery process for individuals affected by NSCLC and other cancers. By highlighting the interplay between physical activity, psychological well-being, and biological health markers, this review aspires to enrich the understanding of how traditional practices like TCC can be effectively utilized within modern cancer care frameworks. Furthermore, the methodology should include a critical appraisal of the quality of the included studies. This assessment should consider factors such as study design, sample size, and the robustness of the biomarkers measured. By evaluating the methodological rigor of the studies, the review could highlight areas of strength as well as potential limitations in the current body of research on TCC and biomarkers in cancer rehabilitation (Xu *et al*., 2019). Ethical considerations, while not directly applicable to this literature review, could still be acknowledged. All studies included in the review should have undergone ethical scrutiny by their respective institutional review boards. This ensures that the research findings synthesized in this review are derived from ethically conducted research, reinforcing the credibility of the conclusions drawn (Xu *et al*., 2019). The methodology outlines a comprehensive literature review approach to evaluate the application of biomarkers in assessing the rehabilitation effects of Tai Chi Chuan in cancer survivors, particularly those with non-small cell lung cancer. By synthesizing existing research, this review aims to contribute valuable insights into the effectiveness of TCC in enhancing recovery and improving health outcomes for cancer survivors. Through careful analysis of biomarkers and health-related quality of life, the review could provide a framework for understanding the potential benefits of integrating TCC into rehabilitation programs for cancer patients (Jiang *et al*., 2023).

3. Results

This section presents the findings from the literature review on the effects of Tai Chi Chuan (TCC) on various biomarkers and health outcomes among cancer survivors. The results are organized around key categories: inflammatory markers, oxidative stress indicators, health-related quality of life (HRQoL), and insights from comparative studies across different cancer types. Each category highlights the contributions of TCC to improving the health and well-being of cancer survivors.

Inflammation response is a critical factor in cancer progression and recovery, making the assessment of inflammatory biomarkers essential for understanding the effects of TCC. Several studies have demonstrated that TCC can lead to

significant reductions in pro-inflammatory cytokines, which are often elevated in cancer survivors. For instance, research has shown that TCC practice is associated with decreased levels of interleukin-6 (IL-6) and tumour necrosis factor-alpha (TNF-α). A systematic review indicated that participants who engaged in TCC exhibited lower IL-6 levels, which correlates with improved health outcomes and diminished cancer-related fatigue (Jiang *et al*., 2023). This reduction in inflammatory markers suggests that TCC may help mitigate the chronic inflammation frequently experienced by cancer survivors, thereby enhancing their recovery and quality of life.

Additionally, TCC has been shown to improve immune function by increasing levels of anti-inflammatory cytokines such as interleukin-10 (IL-10). This shift towards a more balanced immune response is vital for cancer survivors, as it can help reduce the risk of recurrence or secondary malignancies (Xu *et al*., 2019). Furthermore, a study focusing on breast cancer survivors found that regular TCC practice resulted in lower levels of C-reactive protein (CRP), a well-established marker of inflammation. Reduced CRP levels indicate a decrease in systemic inflammation, which can contribute to better overall health outcomes (Xu *et al*., 2019).

The oxidative stress is another important factor affecting cancer survivorship, as it can lead to cellular damage and influence cancer progression. TCC has been shown to have a positive impact on oxidative stress markers, promoting better health outcomes for cancer survivors.

Research indicates that TCC practice enhances the activity of antioxidant enzymes such as superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GPx). These enzymes are crucial for neutralizing free radicals and reducing oxidative stress. For example, a study found that breast cancer survivors who practiced TCC exhibited significantly higher levels of SOD and CAT compared to non-practitioners (Jiang *et al*., 2023). This increase in antioxidant enzyme activity suggests that TCC may help bolster the body's defences against oxidative damage, which is particularly important for cancer survivors. Moreover, TCC has been associated with reduced levels of malondialdehyde (MDA), a marker of oxidative stress and lipid peroxidation. Research involving cancer survivors demonstrated that participants who practiced TCC showed significantly lower MDA levels, indicating a decrease in oxidative stress and potential cellular damage (Song *et al*., 2023). This finding highlights TCC's potential as a therapeutic intervention to improve oxidative stress profiles in cancer survivors.

The impact of TCC on health-related quality of life is a vital aspect of cancer rehabilitation. Numerous studies have highlighted the positive effects of TCC on various dimensions of HRQoL, including physical, emotional, and social well-being. TCC has been shown to improve physical functioning in cancer survivors, which is often compromised due to the effects of cancer treatments. Regular participation in TCC can enhance balance, flexibility, and overall physical fitness, contributing to better mobility and a reduced risk of falls. A systematic review found that breast cancer survivors who engaged in TCC reported significant improvements in physical function and reduced fatigue levels, which are common complaints among this population (Xu *et al*., 2019).

The psychological benefits of TCC are also noteworthy. Studies have reported reductions in anxiety, depression, and stress among cancer survivors who practice TCC. This is particularly relevant given the emotional toll that cancer diagnosis and treatment can have on individuals. For example, a study focusing on breast cancer survivors found that TCC practice was associated with lower levels of anxiety and depression, as well as improved overall mood and emotional well-being (Jiang *et al*., 2023). These psychological benefits are essential for enhancing the overall quality of life for cancer survivors.

TCC is often practiced in group settings, which can foster social interaction and support among participants. This social aspect is crucial for cancer survivors, as it can help combat feelings of isolation and loneliness that may arise during and after treatment. Research has shown that engaging in group TCC sessions can lead to improved social support networks and enhanced feelings of community among cancer survivors (Song *et al*., 2023).

While much of the research on TCC has focused on specific cancer types, findings from studies involving other cancer types also support the benefits of TCC in enhancing biomarkers and overall health outcomes. A study examining the effects of TCC on lung cancer survivors found that participants experienced significant improvements in both physical and psychological health. This study reported reductions in fatigue and anxiety levels, as well as improvements in lung function and exercise capacity among those who practiced TCC regularly (Xu *et al*., 2019). These findings suggest that TCC can be a valuable rehabilitation tool for lung cancer survivors, promoting recovery and enhancing quality of life. Another study involving prostate cancer survivors has also demonstrated the positive effects of TCC on biomarkers and health outcomes. A study found that TCC practice led to improvements in physical function and reductions in fatigue, like findings in breast cancer populations. Additionally, participants reported enhanced emotional well-being and reduced stress levels, highlighting the holistic benefits of TCC for this demographic (Xu *et al*., 2019).

A systematic review encompassing various cancer types indicated that TCC is associated with improved HRQOL, reduced fatigue, and enhanced physical functioning across diverse cancer populations. The review emphasized that TCC's multifaceted benefits make it a suitable intervention for cancer survivors, regardless of their specific diagnosis (Song *et al*., 2023). This broad applicability underscores the potential of TCC as a complementary therapy in cancer rehabilitation.

4. Discussion

The integration of Tai Chi Chuan (TCC) into cancer care has garnered increasing attention due to its potential to enhance biomarkers and improve health outcomes in cancer survivors. This discussion synthesizes findings from various studies, focusing on the effects of TCC on health-related quality of life (HRQOL), inflammatory responses, oxidative stress, and psychological well-being among cancer survivors, particularly those with breast cancer and non-small cell lung cancer (NSCLC).

HRQOL is a crucial measure in evaluating the impact of cancer and its treatment on survivors. Studies have shown that TCC can significantly improve HRQOL in cancer survivors. For instance, a randomized controlled trial involving breast cancer survivors reported significant improvements in HRQOL, fatigue, and emotional well-being following a 12-week TCC intervention (Cao *et al*., 2016). The improvements were associated with reductions in inflammatory markers such as interleukin-6 (IL-6) and C-reactive protein (CRP). These findings suggest that TCC not only enhances physical health but also mitigates the psychological distress often experienced by cancer survivors.

Furthermore, TCC has been shown to improve specific domains of HRQOL, such as physical functioning and social relationships. A comprehensive review highlighted that TCC participants exhibited enhanced physical function, reduced fatigue, and improved social functioning compared to controls. This aligns with findings from other studies emphasizing that TCC helps address treatment-related symptoms such as fatigue, which is prevalent among cancer survivors (Zhou *et al*., 2017). The reduction of these symptoms can significantly enhance overall HRQOL, making TCC a valuable intervention in supportive cancer care.

The immune system's role in cancer recovery is critical, particularly in combating residual cancer cells and managing treatment side effects. Research has demonstrated that TCC can enhance immune function by modulating inflammatory responses. For example, a study found that TCC practitioners exhibited increased natural killer (NK) cell activity, which is vital for immune surveillance and the destruction of tumour cells (Li *et al*., 2018). This enhancement of NK cell activity is particularly important for cancer survivors, as it may reduce the risk of recurrence. Moreover, the reduction of pro-inflammatory cytokines is another mechanism through which TCC exerts its beneficial effects. Elevated levels of IL-6 and TNF-α are associated with various negative health outcomes, including fatigue and depression in cancer survivors. A meta-analysis of TCC interventions across different cancer populations indicated significant reductions in these inflammatory markers, supporting the notion that TCC can help mitigate chronic inflammation associated with cancer survivorship (Gong *et al*., 2020). Additionally, CRP levels, a well-known marker of systemic inflammation, were found to decrease significantly in cancer survivors participating in TCC programs. This finding is particularly relevant as elevated CRP levels have been linked to poorer prognosis in various cancers, including breast and lung cancer (Davis *et al*., 2018). By reducing systemic inflammation, TCC may contribute to improved health outcomes and lower recurrence rates among cancer survivors. Oxidative stress plays a pivotal role in cancer progression and treatment-related complications. TCC has been shown to positively influence oxidative stress markers, promoting better health outcomes. For instance, a study involving breast cancer survivors reported that participants practicing TCC exhibited increased levels of antioxidant enzymes, such as superoxide dismutase (SOD) and glutathione peroxidase (GPX) (Wang *et al*., 2019). These enzymes are crucial for mitigating oxidative damage and maintaining cellular health. Furthermore, reductions in markers of oxidative stress, such as malondialdehyde (MDA), have been observed in TCC practitioners. A systematic review highlighted that TCC significantly lowered MDA levels, indicating a decrease in lipid peroxidation and oxidative stress among participants (Zhao *et al*., 2019). This reduction in oxidative stress is particularly beneficial for cancer survivors, as it may help reduce the risk of secondary malignancies and improve overall health. The modulation of the KEAP1-NRF2 pathway, which regulates antioxidant responses, is another mechanism through which TCC may exert its effects on oxidative stress. Research has suggested that TCC can enhance NRF2 activity, leading to increased expression of antioxidant genes and decreased oxidative damage (Li *et al*., 2021). This pathway's activation may be particularly important for cancer survivors, as it helps protect against the oxidative stress associated with cancer treatment.

The psychological benefits of TCC are significant, particularly in reducing anxiety and depression among cancer survivors. Studies have consistently shown that TCC can lead to substantial reductions in anxiety and depressive symptoms. For instance, a meta-analysis found that TCC significantly improved psychological well-being, with

participants reporting lower levels of anxiety and depression compared to control groups (Cao *et al*., 2018). This is particularly relevant for cancer survivors, who often experience heightened levels of psychological distress following diagnosis and treatment. The mindfulness component of TCC, which emphasizes relaxation and mental focus, may contribute to these psychological benefits. Research has shown that mindfulness practices can reduce stress and improve emotional regulation, which are crucial for cancer survivors managing the psychological aftermath of their diagnosis (Carlson *et al*., 2016). TCC's meditative aspects may foster a sense of control and well-being, helping survivors cope with the emotional challenges associated with their experiences. Additionally, the social interaction inherent in group TCC classes can enhance social support networks among cancer survivors. Engaging in a supportive community can mitigate feelings of isolation and promote a sense of belonging, which is essential for emotional health during recovery (Zhou *et al*., 2017). The combination of physical activity, social engagement, and mindfulness makes TCC a holistic approach to improving both physical and mental health in cancer survivors.

While much of the research on TCC has focused on specific cancer types, findings from studies involving various cancer populations support the benefits of TCC in enhancing biomarkers and overall health outcomes. For example, a study examining the effects of TCC on lung cancer survivors found that participants experienced significant improvements in physical functioning and reductions in fatigue, similar findings in breast cancer populations (Tsang *et al*., 2016). These results suggest that TCC can be a valuable rehabilitation tool for lung cancer survivors, promoting recovery and enhancing quality of life. Moreover, research involving prostate cancer survivors has also demonstrated the positive effects of TCC on biomarkers and health outcomes. A study found that TCC practice led to improvements in physical function and reductions in fatigue, highlighting the holistic benefits of TCC for prostate cancer survivors (Zhang *et al*., 2020). These findings underscore TCC's applicability across diverse cancer populations, reinforcing the idea that it can serve as a complementary therapy in cancer rehabilitation.

Understanding the mechanisms through which TCC exerts its effects on biomarkers and health outcomes is essential for optimizing its application in cancer rehabilitation. The mind-body approach of TCC emphasizes the integration of physical movement, breath control, and mental focus, which can enhance the mind-body connection. This holistic approach may contribute to improved psychological well-being and reduced stress levels among cancer survivors (Li *et al*., 2017).

Moreover, TCC is a form of low-impact exercise that can be easily adapted to accommodate individuals with varying levels of physical ability. This adaptability makes it an ideal intervention for cancer survivors, many of whom may experience physical limitations due to treatment side effects. Regular participation in TCC can help improve physical fitness, balance, and flexibility, which are crucial for enhancing overall health and reducing the risk of complications (Liu *et al*., 2018). The biological pathways influenced by TCC, including those related to inflammation and oxidative stress, further elucidate its potential benefits. TCC has been shown to modulate the KEAP1-NRF2 signaling pathway, enhancing the body's antioxidant defences and reducing oxidative stress (Wang et al., 2019). This modulation is particularly important for cancer survivors, as it helps protect against the oxidative damage associated with cancer treatment and recurrence.

Given the evidence supporting the benefits of TCC for cancer survivors, there are important implications for clinical practice. Integrating TCC into survivorship care plans could provide a valuable adjunct to conventional treatments. Healthcare providers should consider recommending TCC as part of a comprehensive approach to managing the long-term effects of cancer treatment. This could involve referrals to local TCC classes or the development of structured programs within cancer care facilities.

Limitations of the review

While the benefits of TCC are evident, several challenges and limitations must be considered. One significant challenge is the variability in TCC styles and practices, which may influence the outcomes observed in different studies. Standardizing TCC interventions and protocols should be essential for achieving consistent results and facilitating comparisons across studies. Additionally, many studies on TCC and cancer survivorship have small sample sizes or lack control groups, which can limit the generalizability of the findings. Future research should aim to include larger, well-designed studies with appropriate control groups to strengthen the evidence base for TCC as an effective intervention for cancer survivors. Another point is the potential for publication bias, as studies with positive results are more likely to be published than those with null or negative findings. This bias can skew the perceived effectiveness of TCC and may lead to overestimations of its benefits. Researchers should strive to report all findings, regardless of the outcome, to provide a more accurate picture of TCC's efficacy.

Furthermore, further research is needed to establish standardized protocols for TCC interventions tailored to the needs of cancer survivors. Future studies will focus on larger, more diverse populations to validate the findings and explore the long-term effects of TCC on biomarkers and HRQOL. The investigating the optimal frequency and duration of TCC practice could help maximize its benefits for cancer survivors.

5. Conclusion

Integrating Tai Chi Chuan (TCC) into rehabilitation programs for cancer survivors, particularly breast cancer patients, shows significant promise in enhancing health-related quality of life (HRQOL) and modulating biomarkers associated with treatment side effects. Evidence suggests that TCC can lead to substantial improvements across various HRQOL domains. For example, a study indicated that participants engaging in TCC reported significant enhancements in physical functioning, emotional well-being, and overall HRQOL compared to those receiving standard care.

The relationship between biomarker changes and HRQOL improvements further highlights the potential biological mechanisms through which TCC exerts its effects. Studies have shown that TCC practice is associated with reductions in inflammatory cytokines, such as interleukin-6 (IL-6) and tumour necrosis factor-alpha (TNF-α). These cytokines are known to contribute to cancer-related fatigue and other debilitating symptoms. By reducing systemic inflammation, TCC may alleviate some of the burdens faced by cancer survivors, thereby enhancing their overall well-being.

Moreover, the modulation of insulin-like growth factor-1 (IGF-1) and cortisol levels has been observed in TCC participants, correlating with improvements in physical role limitations and overall health perceptions. This suggests that TCC may influence metabolic and stress-related pathways that significantly affect survivors' quality of life.

The findings underscore the importance of holistic approaches in cancer survivorship care, where interventions like TCC not only address physical health but also enhance psychological and social dimensions of recovery. The multifaceted benefits of TCC are crucial as cancer survivors frequently encounter long-term challenges that extend beyond their physical health, including emotional distress and social isolation. Thus, incorporating TCC into survivorship programs could serve as a valuable strategy to improve HRQOL and manage the lingering effects of cancer treatment.

Further studies should focus on several key areas to elucidate the benefits of TCC for cancer survivors. Firstly, larger scale randomized controlled trials are essential to validate findings from smaller studies and assess the long-term effects of TCC on HRQOL and biomarkers across diverse cancer survivor populations. These studies should aim for a varied demographic to understand how factors such as age, cancer type, and treatment history may influence TCC outcomes. Secondly, exploring the specific mechanisms by which TCC influences biomarker levels and HRQOL is imperative. Investigating the pathways involved in the modulation of inflammatory and metabolic markers could provide deeper insights into how TCC contributes to physical and psychological recovery. Longitudinal studies tracking biomarker changes in relation to TCC participation should be beneficial. Thirdly, integrating qualitative research methods could enrich our understanding of the survivor experience with TCC. Utilizing interviews and focus groups may uncover personal insights into how TCC impacts emotional and social well-being, which quantitative measures might not fully capture. Finally, there is a need to develop tailored TCC programs that address the specific needs of different cancer survivor groups. Customizing interventions based on individual health profiles and preferences could enhance engagement and effectiveness, ultimately leading to improved health outcomes for survivors.

In conclusion, TCC presents a promising avenue for improving HRQOL among cancer survivors, and future research should aim to expand upon these findings to optimize survivorship care.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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