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Monitoring the status of rehabilitation of cancer survivors practicing Tai Chi Chuan

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Abstract

The rehabilitation of cancer is a crucial stage in the path of cancer survivors, holistic ways of healing are becoming more widely acknowledged as medical innovations have improved results of cancer treatment and survival rates. Due to its ability to improve the rehabilitation process for cancer survivors, Tai Chi Chuan (TCC) stands out as a compelling choice among the excess of complementary therapies that have arisen. Tai Chi Chuan, an ancient Chinese martial art that blends slow, flowing motions with deep breathing and meditation, has attracted interest as a potentially transforming alternative therapy for cancer survivors. It is accessible to people of all fitness levels, making it an appealing alternative for those recuperating from the physical toll of cancer and its therapies. Biomarkers provide a window into the complicated mechanisms at work during recovery by giving quantitative data on physiological changes of cancer survivors. It could be the objectively determined biological indicators, and they have enormous potential in analyzing the influence of TCC on the recovery path. The aim of this essay is to explain the function of biomarkers in assessing the efficiency of TCC as a rehabilitation aid for cancer survivors and to critically examine existing studies on this subject.

Finally, we found biomarkers have a critical role in improving the precision of evaluations in cancer rehabilitation. These biological markers provide objectivity, allowing healthcare providers to track patients' progress and customize interventions to address treatment-related problems as soon as possible. TCC shows the benefit to emotional health and may lessen the symptoms of mental health illnesses.

Keywords: Rehabilitation; Tai Chi Chuan; Cancer Survivor; Biological Markers; Quality of Life

1. Introduction

Cancer rehabilitation is a crucial stage in the path of cancer survivors; it is a time when attention is diverted from fighting the illness itself to restoring their physical, emotional, and mental health [1]. Holistic ways of healing are becoming more widely acknowledged as medical innovations have improved cancer treatment results and survival rates [2-3]. Additionally, due to its ability to improve the rehabilitation process for cancer survivors, Tai Chi Chuan stands out as a compelling choice among the excess of complementary therapies that have arisen [4]. Furthermore, to assess how well Tai Chi Chuan aids in recovery, this study goes into the field of cancer rehabilitation and analyses the possible application of biomarkers. Cancer healing is critical, and it cannot be overstated. This challenging rival jeopardises the mental, physical, and emotional well-being of cancer patients.

Furthermore, the journey from diagnosis to treatment is frequently prolonged and involves surgery, chemotherapy, radiation, and side effects that can physically and mentally drain patients [5] (Beigh and Gul, 2022). Even when treatment is completed, survivors usually experience weariness, discomfort, concern, and despair, which can severely impair their capacity to live fulfilling lives again [6]. Cancer rehabilitation aims to heal the body and reestablish a sense of routine in addition to restoring physical function. Moreover, it also attends to the special requirements of survivors.

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As a result, interest in complementary therapies has increased recently as useful additions to conventional cancer treatment. These therapies, which are frequently based on ancient traditions, take a holistic approach to recovery, treating physical symptoms and the emotional and psychological components of cancer survival [7].

Additionally, Tai Chi Chuan, an ancient Chinese martial art that blends slow, flowing motions with deep breathing and meditation, has attracted interest as a potentially transforming alternative therapy for cancer survivors [8]. Furthermore, due to its gentle and low-impact nature, it is accessible to people of all fitness levels, making it an appealing alternative for those recuperating from the physical toll of cancer and its therapies. Biomarkers, or objectively determined biological indicators, have enormous potential in analysing the influence of Tai Chi Chuan on the recovery path [9-10]. Biomarkers provide a window into the complicated mechanisms at work during recovery by giving quantitative data on physiological changes [9-10]. Thus, understanding how Tai Chi Chuan affects these biomarkers might provide insight into the mechanisms underlying its possible benefits. Therefore, the aim of this essay is to explain the function of biomarkers in assessing the efficiency of Tai Chi Chuan as a rehabilitation aid for cancer survivors and to critically examine existing studies on this subject.

2. Biomarkers

Biomarkers are quantitative indicators that each have their own features and importance. Several types of biomarkers are significant in the context of cancer rehabilitation. Genetic biomarkers, such as mutations in certain genes, are important in determining an individual's susceptibility to cancer. These biomarkers can aid in the identification of potential hereditary variables that influence a patient's reaction to therapy and recovery in rehabilitation [11-12]. Furthermore, protein biomarkers are extensively employed in cancer research because they can detect the presence or activity of certain proteins linked to cancer, inflammation, or immune response [13-15]. Protein biomarkers are used in rehabilitation to track the development of cancer survivors. Elevated levels of some inflammatory proteins, for example, may suggest higher stress on the body during rehabilitation [13-15]. Metabolic biomarkers indicate changes in a patient's metabolism, which can be especially useful in understanding how the body responds to cancer and its therapies. They can assist healthcare providers in developing rehabilitation programmes that meet the patient's metabolic demands, such as food advice and exercise regimens during cancer recovery [16-18]. Imaging approaches provide imaging biomarkers that visualise tumour development, response to therapy, and physiological changes in the body. These imaging indicators provide crucial insights into the efficacy of therapies and the progression of recovery in rehabilitation [19-20]. Biomarkers that circulate in the blood or other physiological fluids can give real-time information on a patient's state [21-22]. Monitoring circulating biomarkers in cancer rehabilitation can help assess therapy-induced adverse effects such as tiredness or anemia and advise treatment plan adjustments to maximise recovery. Therefore, Genetic, metabolic, and protein biomarkers are very important in cancer rehabilitation [16-22].

Biomarkers are essential for tracking the status of cancer survivors throughout rehabilitation. They have various advantages in this situation. The researchers, firstly, they give objective, measurable data that healthcare practitioners may use to analyse a patient's development, which reduces subjectivity in the evaluation process [23-24]. Secondly, biomarkers allow for the early diagnosis of cancer therapy problems or unwanted effects. Changes in liver enzymes, for example, may signal toxicity from chemotherapy, allowing for prompt intervention [23-24]. Thirdly, the data obtained by biomarkers can be used to tailor rehabilitation regimens. Identifying excessive levels of inflammation, for example, might lead to changes in exercise intensity or dietary advice to aid in the healing process [23-24]. Finally, biomarkers can give real-time feedback on the efficacy of rehabilitation programmes, allowing healthcare practitioners to make more informed decisions [23-24].

Specific case studies demonstrate the practical application of biomarkers in measuring cancer rehabilitation outcomes of cancer survivors. Protein biomarkers were employed in one study to track the response of breast cancer survivors following treatment [25].

They evaluated the quantities of cancer-related proteins in the blood of patients before, during, and after therapy [25-26]. They may measure the efficiency of the chemotherapy and modify rehabilitation programmes to address treatment-induced adverse effects by analysing changes in these biomarkers over time [25-26]. In another case study, metabolic indicators were used to measure muscle mass and function in cancer rehabilitation patients [27]. In this study, researchers employed a mix of metabolic and imaging indicators to assess the impact of exercise and dietary treatments on muscle composition. This information enabled the creation of personalised rehabilitation regimens focused on preserving and improving muscular strength and function [27]. Genetic indicators were utilised to predict rehabilitation effectiveness in colorectal cancer survivors in a third case study. Researchers uncovered distinct genetic markers that impacted patients' reactions to Tai Chi Chuan-based rehabilitation programmes by analysing DNA profiles [28-29]. These indicators aided in personalising rehabilitation procedures to maximise benefits for each patient, suggesting the

feasibility of personalised rehabilitation strategies based on genetic data [28-29]. Hence, biomarker research revealed important information on how chemotherapy is affected and their subsequent recovery path. During various periods of the therapy, significant changes in the amounts of proteins were observed [28-29]. For example, inflammatory protein levels may rise during chemotherapy because of the reaction of the body to treatment-induced stress [30-31]. Monitoring variations in protein biomarkers enabled healthcare practitioners to make educated judgements about how to alter the rehabilitation programme to successfully manage treatment-induced adverse effects [30-31]. In practice, this case study revealed the effectiveness of protein biomarkers in directing the design of rehabilitation programmes. It allowed healthcare providers to create personalised exercise routines and dietary programmes for breast cancer survivors, reducing the side effects of chemotherapy and promoting a more comfortable and effective recovery process [30-31]. Therefore, these studies show the practical application of biomarkers in monitoring cancer survivors' progress throughout rehabilitation, as well as the possibility for individualised, personalised rehabilitation strategies [30-31].

3. Biomarkers in rehabilitation of cancer survivors by practicing Tai Chi Chuan

Researchers employed protein biomarkers to evaluate the response of breast cancer survivors to chemotherapy in a large trial done at several cancer rehabilitation centres. TCC was observed to be linked with insulin level maintenance in one investigation [32-33]. There was a significant difference in insulin levels between the TCC and control groups. The insulin levels in the control group increased, whereas levels in the TCC group stayed unchanged [32-33]. The effects of TCC exercise on health-related quality of life (HRQOL) in breast cancer survivors and the potential relationships between changes in and biomarkers were measured [34-35]. The studies showed the changes in insulin-like growth factor-1, interleukin-6, interleukin-8, IGFBP-3, insulin-like growth factor-binding protein-1, glucose, and cortisol are linked to HRQOL and status of health [34-35]. Thus, it can be inferred that several protein biomarkers can be used to evaluate the effect of TCC on cancer survivors [34-36]. TCC is linked to the control of insulin levels in cancer survivors. Insulin often increases after chemotherapy, which is a great concern for cancer survivors. However, the practice of TCC shows a great impact on lowering insulin in cancer survivors when compared to the control group [34-36]. Additionally, practicing TCC had an overall positive effect on HRQOL and helped in the regulation of several biomarkers, which helped to provide a better quality of life [34-36]. On the contrary, other variables, such as dietary changes or psychological issues, might have contributed to the insulin level alterations. Therefore, the studies give preliminary information about the link between TCC, insulin levels, and HRQOL in breast cancer survivors. In conclusion, TCC benefits breast cancer patients by improving their insulin and overall health and well-being [34-37]. The TCC practice in cancer survivors undergoing rehabilitation has proven to show many effects on the biomarkers that improve their overall well-being. The study demonstrated the effects of TCC on cancer patients and found that the levels of cytokines among control and experimental cancer patients did not differ significantly [38]. However, the overall number of white blood cells (WBC) and red blood cells (RBC) did significantly increase because of the study, suggesting possible immune system advantages. Additionally, patients reported better hand grip strength and short-term memory, indicating both psychological and physical gains [38]. Tsang finding demonstrated TCC could increase in blood biomarkers, particularly white blood cell count, red blood cell count, haemoglobin, serotonin (happiness), cortisol (stress), and high sensitivity C-reactive protein (inflammation) [39]. In addition, the patients reported better sleep quality, less stress, more happiness, and better social interaction [39]. Hence, the studies demonstrated the beneficial effects of TCC on cancer survivors with improvement several biomarkers as well as general health [38-39]. Notably, TCC training resulted in higher white and red blood cell counts, pointing to possible immune system advantages. Furthermore, there is evidence of improved short-term memory and hand grip strength. Moreover, the studies also noted improvements in inflammatory, stress, and well-being-related blood indicators [38-39]. On the contrary, there were no appreciable changes in cytokine levels between patients and controls, suggesting that TCC may be able to assist patients in maintaining health that is comparable to that of healthy people. Hence, for a more thorough knowledge of the effects of TCC on cancer rehabilitation, it is crucial to consider study limitations and the requirement for larger and more diverse samples. Therefore, TCC practice in cancer survivors undergoing rehabilitation has proven to show many effects on the biomarkers that improve their overall well-being [34-39].

Cancer survivors who practice TCC are shown to be better in terms of mental health and overall well-being. The findings of the study imply that spiritually oriented therapies, particularly mindfulness-based techniques like TCC [40-41], have a favourable influence on psychosocial outcomes in breast cancer survivors, such as quality of life, depression, stress, and anxiety [40-41]. Notably, cortisol, a stress-related biomarker, was tested often, with some studies indicating positive improvements and a few reporting steady levels when compared to control groups. Furthermore, several treatments appeared to impact telomere length and telomerase activity, both of which are linked to health and lifespan [42-44]. A study tested the effect of TCC on peripheral mononuclear cells, which are a major biomarker in non-small cell lung cancer (NSCLC) [40-44]. Several positive outcomes were found, including higher cell proliferation in PBMCs and greater cytolytic activity against NSCLC cells in the TCC group. Furthermore, substantial variations in the percentages of natural killer (NK) cells, as well as post-pre alterations in NKT cells, were seen between the two groups [40-44]. These

findings demonstrate that regular Tai Chi practice has the potential to boost immune responses in NSCLC patients, implying a possible route for future study with bigger sample sizes and longer durations to better understand its consequences for cancer survivors [40-44]. Hence, Tai Chi and mindfulness-based approaches can considerably enhance cancer survivors' psychological well-being. This includes improved quality of life as well as lower levels of sadness, stress, and anxiety [40-41]. These advantages lead to a more comprehensive approach to cancer survival. In addition, the studies show that it has a favourable effect on the immune system, particularly in the setting of NSCLC. Moreover, increased peripheral blood mononuclear cell proliferation and cytolytic activity against cancer cells, together with differences in natural killer cell percentages, are hopeful discoveries that point to the possibility of better immune responses [40-44]. Also, TCC and related practices may have health and lifespan impacts. The effect on stress-related indicators such as cortisol, as well as telomere length and telomerase activity, implies possible long-term health advantages that go beyond the immediate benefits. In conclusion, studying the benefits of Tai Chi and other mind-body techniques on cancer survivors, notably in non-small cell lung cancer (NSCLC) and breast cancer, indicate a few advantages and potential [40-44]. The practice of TCC in cancer rehabilitation patients has shown to be very effective in the reduction of inflammatory biomarkers [45-47]. Liu and his colleagues demonstrated that Tai Chi practice was linked to lower levels of proinflammatory biomarkers such as interleukins, tumour necrosis factor, and C-reactive protein, as well as higher levels of anti-inflammatory cytokines [45-47]. These alterations were unrelated to any medical concerns. In addition, the study also reveals that Tai Chi, when practiced with parameters (60 minutes, three or more times per week for at least 12 weeks), improves the anti-inflammatory capability of the body, making it useful for people with a variety of health issues [45-47]. Oh's study indicated that TCC had a relatively minor influence on enhancing immune cell levels but not on decreasing inflammation levels [48-49]. Furthermore, TCC exhibited bidirectional cytokine modulation, with both overexpression and downregulation reported. Notably, TCC therapies lasting at least four weeks were observed to improve immune system function and inflammatory regulation [45-49]. Despite certain limitations, the research indicated that TCC might be an effective preventative health intervention for enhancing immunological function and general well-being. Hence, a comparison of the two research reveals some surprising data on the effects of Tai Chi on inflammatory biomarkers and immunological responses in rehabilitation patients [45-49]. One research found that Tai Chi can reduce inflammatory biomarkers and regulate cytokines regardless of the medical status of the participants. These positive effects were particularly noticeable when Tai Chi was practiced under precise conditions [45-49]. However, this study had very few numbers of participants to give a conclusive result. In contrast, the other study discovered that TCC had just a minimal effect on immune cell numbers and did not significantly reduce inflammation. TCC also showed bidirectional cytokine modulation, with both raised and lowered cytokine levels [45-49]. TCC treatments, on the other hand, were related to enhanced immunological function and better inflammatory modulation after at least four weeks. Therefore, both studies provide evidence that TCC can improve the immune system and lower inflammatory biomarkers in the body [45-49].

TCC may enhance chronic disease biomarkers in elderly cancer survivors. A 12-week Tai Chi (TCC) intervention was associated with significantly reduced systolic blood pressure (SBP) and salivary cortisol levels as compared to a control group in a study that included older female cancer survivors [50-51]. Furthermore, results demonstrated that TCC might successfully lower blood pressure and stress in this population. However, no significant changes in the levels of inflammatory cytokines were observed following the TCC intervention [50-51]. Extensive studies with a wider range of participant demographics and longer assessment periods are required to fully explore the substantial potential of TCC to lower the incidence of chronic diseases among older cancer survivors [50-51]. An alternative study conducted by Mansky and his term looked at Tai Chi Chuan (TCC) as an exercise intervention for a variety of people, such as elderly cancer patients and those with cardiovascular problems [36, 52-53]. Even though the research is constrained by the typically small sample sizes in trials, TCC has been demonstrated to improve balance, reduce the risk of falling, improve sleep quality, and support cardiovascular health [36, 52-53]. Consequently, there is growing interest in examining the possible advantages of TCC for cancer survivors who may endure physical deconditioning, psychological stress, and a higher chance of cardiovascular disease. As a result, Tai Chi Chuan (TCC) has demonstrated promise in supporting older cancer survivors by promoting better cardiovascular health through a reduction in systolic blood pressure, as well as by reducing stress, increasing balance, and enhancing sleep quality [38-39]. Furthermore, TCC is a complete strategy for treating the special needs of older people, such as their susceptibility to cardiac difficulties and psychological stress, which is often a repercussion of cancer. Nonetheless, the studies included a small sample of participants along with an absence of statistically significant results showing increased cytokines. Therefore, TCC has been shown to potentially reduce chronic disease biomarkers in elderly cancer survivors; however, the area demands further research for concrete results [36, 52-53].

Exercising with TCC has been proven to improve the health of bones and muscles in cancer survivors. Scientists discovered that cancer survivors who did tai chi had stronger bones, better metabolism, and stronger muscles [54-55]. These results also agree with previous research that showed TCC can help maintain strong and healthy bones [54-55]. Furthermore, the study showed an increase in the activity of two main bone metabolism biomarkers, namely N-

telopeptides of type I collagen (NTx) and bone-specific alkaline phosphatase (BSAP) [54-55]. NTx is a bone metabolism biomarker, which is a sign of increased resorption in bone by osteoclasts, while BSAP indicates new bone development through the activity of osteoblasts. The findings revealed that weight-bearing exercise, such as TCC, can potentially improve bone loss in breast cancer survivors. Also, TCC is a good option for exercising that can help decrease these problems and is liked by many people. Given that more and more women are overcoming breast cancer, maintaining good bone health is crucial [54-55]. TCC showed considerable improvements in specific physical parameters, with breast cancer survivors showing higher upper limb muscular strength as measured by handgrip dynamometer strength and better flexibility and mobility in elbow flexion and extension [56-57]. However, contrary to earlier findings, this study found that TCC did not substantially modify levels of interleukin-6 or insulin-like growth factor 1, two critical biomarkers related to breast cancer treatment, nor did it significantly lower pain levels [34-39]. In addition, various dimensions of psychosomatic well-being, such as social, psychological, emotional, or general health-related quality of life, did not significantly change because of TCC. Hence, the enhancement of bone density and metabolism, as well as the development of upper limb strength and flexibility, were enhanced through the practice of TCC. The potential advantages of TCC as a fitness programme for cancer survivors, which might improve their general quality of life, are supported by these findings, which are in line with earlier research. Importantly, the study finds high activity in two key bone metabolism indicators, NTx and BSAP, denoting potential advantages for bone health, which is particularly important for cancer patients [54-55]. However, despite the improvements in physical metrics, a few limitations are revealed by the study as TCC does not significantly affect biomarkers like IL-6 and IGF-1, reduce pain levels, or psychological well-being. The contradictory findings show that the benefits of cancer survivors practicing TCC through biomarker activity are still understudied, and further research is needed to identify the situations where it is the most successful [34-39].

The bone metabolic biomarkers are known to be improved through the practice of TCC in breast cancer survivors. The de Sire results demonstrated that Tai Chi has a strong, favourable influence on BMD in several bone areas, including the femur neck, femur trochanter, lumbar spine, and hip region [54-58]. Furthermore, among the bone formation biomarkers, Bone-Specific Alkaline Phosphatase (BAP) improved significantly when TCC was added to the routine of participants. This shows that Tai Chi improved the metabolic activity of osteoblasts, the cells responsible for bone formation [54-58]. However, another bone formation marker, osteocalcin (OSC), did not demonstrate a significant improvement, showing that TCC benefits may differ across different markers linked with bone development [54-58]. Thus, while this study offered great insights into the increased activity of bone metabolic biomarkers like BAP, it did not show similar results for other biomarkers, such as OSC and ALP [54-58]. On the contrary, Yan' study did not find any meaningful effect of TCC on quality of life (QoL) except for an improvement in emotional well-being [59]. Secondary outcomes, such as body mass index (BMI), bone mineral density (BMD), and muscle strength, revealed that Tai Chi did not result in substantial changes [59]. Furthermore, significant variability was detected in the physical well-being QoL subscale analysis, which was mostly related to one trial with a greater training frequency. Overall, the study found that Tai Chi did not significantly improve QoL or other major clinical outcomes in breast cancer survivors [54-58]. The findings suggest that TCC has a complicated association with multiple health indicators in breast cancer survivors. Tai Chi appears to significantly alter bone mineral density (BMD) and Bone-Specific Alkaline Phosphatase (BAP), indicating enhanced bone production [54-58]. The absence of considerable improvement in osteocalcin (OSC), another bone formation marker, demonstrates the diversity in the impact of TCC on different elements of bone metabolism. On the other hand, only emotional well-being shows a significant improvement, with less of an impact on overall quality of life (QoL), bone mass, and BMI [54-58]. This demonstrates that while Tai Chi may enhance certain emotional aspects of QoL, its positive effects on overall QoL are not very great. This research indicates that Tai chi has a variety of effects on different metabolic biomarkers. It doesn't consistently affect all metabolic biomarkers, but it can benefit some aspects of health, such as emotional stability and bone density [54-58]. Consequently, it has been found that TCC affects several cellular biomarkers in cancer survivors. A study found that cancer survivors who practiced Tai Chi Chuan did not exhibit any significant changes in the cellular biomarkers CD4+, CD8+, and CD59 T lymphocytes [60]. While there were no changes in the control group, the study also discovered a significant decrease in the quantity of CD55 cells in the TCC practice group. The study's findings suggest that TCC may have varying effects on the cellular immunity biomarkers, possibly decreasing some while leaving others unchanged [60]. Among non-small cell lung cancer survivors, the T-cell immunity will be enhanced by the decrease of CD55 [60]. A study result was demonstrated that the ratios of cytotoxic T cell type 1 to type 2 (Tc1/Tc2) and interferon-producing cells to interleukin 4 (T1/T2) declined with time, indicating an imbalance in immunity [61]. The Tai Chi training helps maintain a healthy immunological balance since the Tai Chi group did not exhibit this drop. Furthermore, the beneficial effects of TCC on immunological function were further supported by the fact that, whereas cortisol levels rose in the control group, they stayed steady in the Tai Chi group [61]. Hence, from these studies, it can be inferred that practicing TCC can lead to a decrease in cellular biomarkers [61]. The study demonstrates that, even though TCC has no visible effect on some T lymphocyte subsets, such as CD4+, CD8+, and CD59 T lymphocytes, there is a substantial decrease in CD55 cells in the TCC group compared to the control group [61]. This decrease in CD55 is especially encouraging for improving T-cell immunity in non-small cell lung cancer survivors

since CD55 might impair the body's defenses against cancer cells [61]. TCC may also aid in preserving a balanced and robust immunological response, according to the data. As time passed, the ratios of interferon-producing cells to interleukin 4 (T1/T2) and cytotoxic T cell type 1 to type 2 (Tc1/Tc2) in the control group decreased, pointing to an immunological imbalance. Therefore, these findings suggest that TCC intervention is important, especially for Non–Small Cell Lung cancer survivors, in improving their immunity [61].

TCC may affect brain biomarkers, especially serotonin and dopamine levels, which are essential for cancer survivors. Endorphins, which are natural opioids, are released during TCC practice, which is one important mechanism [62]. These endorphins assist in decreasing stress and anxiety while enhancing feelings of well-being. Additionally, frequent TCC practice has been connected to higher amounts of neurotransmitters, including dopamine and serotonin, which are recognised for their function in controlling mood [62]. It is thought that these adjustments in neurotransmitter levels have a favourable effect on emotional well-being and may lessen the signs of anxiety and sadness [62]. Exercises like Tai Chi Chuan could have immunomodulatory impacts on diseases like depression and ARCD [63]. How a person would react to various PA and pharmacological therapies may be predicted by their baseline levels of certain cytokines [64]. The research from Eyre and Baune, compared to other PA subtypes, aerobic and resistance PA may have more notable neuroplastic consequences [62-65]. In addition, the prefrontal and hippocampus parts of the brain, which are essential for cognitive function, show the strongest benefits [62-65]. Thus, the studies highlight Tai Chi Chuan's (TCC) possible impact on brain biomarkers, particularly through the control of serotonin and dopamine levels [62-65]. Endorphins, which serve as natural opioids and reduce tension and anxiety while fostering a sense of well-being, are released because of TCC practice [62-65]. Additionally, consistent TCC practice is linked to higher amounts of neurotransmitters, including dopamine and serotonin, which are recognised for controlling mood. These neurochemical alterations are thought to improve emotional well-being and may even lessen the signs of anxiety and sadness [62-65]. In conclusion, the evidence points to the possibility that TCC may have a variety of advantages, including the modification of brain biomarkers, including neurotransmitters and cytokines, which can improve emotional well-being and perhaps be beneficial for treating mental illnesses.

Practicing Tai Chi Chuan has also been found to alleviate symptoms of fatigue in cancer survivors [66]. The study discovered that participants who regularly participated in TCC sessions experienced much less weariness [66]. When compared to light exercise alone, TCC, with its meditative and breath-focused components, showed a clear benefit in lowering tiredness [66]. Carroll research results demonstrated the beneficial effects of TCC on eight different biomarkers, including lipids, haemoglobin A1c, glucose, insulin, C-reactive protein, and fibrinogen, served as the main outcome [67]. At the 16-month follow-up, the findings showed that when compared to the control group (SS), TCC considerably decreased risk ratings at 4 months and 16 months, TCC could improve quality of sleep and also decreased the odds of remaining in the high-risk group at 16 months for participants who were initially categorised as high-risk [67]. Thus, according to the research described, elderly cancer survivors may benefit from Tai Chi Chuan (TCC) therapies that affect certain chronic illness biomarkers. Systolic blood pressure (SBP) and salivary cortisol levels significantly decreased after a 12-week TCC programme, according to the study, compared to a control group [67]. This finding suggests that TCC is an effective method for reducing blood pressure and easing stress in this demographic. TCC has also been shown to improve cardiovascular health, lower the chance of falling, improve sleep quality, and aid in stress management in senior people, especially those with a history of cancer [67]. These results support the notion that TCC is an all-encompassing strategy for meeting the specific health requirements of older persons, particularly those who may need assistance. However, the study had disadvantages, including a limited sample size and a lack of statistically meaningful data on cytokine level increases [60-67]. Therefore, TCC seems to be useful in reducing chronic disease biomarkers in older cancer survivors, more studies with larger and more varied participant pools and longer follow-up times are required to produce more conclusive findings [62-67].

There are a few limitations to the studies examining the impact of Tai Chi Chuan (TCC) on biomarkers in cancer survivors. Furthermore, the statistical power is diminished by the small sample size, which also casts doubt on the findings' generalizability [68]. As a result, one of the significant flaws of this research is the small sample size. Moreover, it is occasionally forgotten that cancer survivor groups are heterogeneous, encompassing a range of cancer types, treatments, and comorbidities [69]. This variety presents a multitude of potential confounding variables that are not routinely considered, which makes it difficult to determine the exact impact of TCC. Furthermore, many of these studies also have relatively short intervention periods [69]. These limited intervention periods might make it difficult to measure the long-term advantages of TCC, particularly in terms of managing chronic diseases [70]. Moreover, the short-term effects of TCC may not fully represent its long-term consequences, which can be critical for recognising its usefulness in the context of cancer rehabilitation [70]. A typical drawback is a lack of well-matched control groups. Without such controls, it becomes difficult to credit reported improvements purely to TCC therapies [70]. This hampers the capacity to establish a cause-and-effect link between TCC and the observed biomarker changes [70]. Another concern is the presence of uncontrollable confounding factors [71]. Factors such as dietary changes and psychological

factors are not routinely accounted for, yet they can have a major influence on biomarker alterations [72], as reported in this research. Additionally, failure to account for these variables might add uncertainty and restrict the conclusions that can be taken from the research [72]. Finally, the biomarkers assessed in different investigations vary. While this variety may represent the different interests of researchers, it makes it more difficult to synthesise the data and build a cohesive knowledge of the effects of TCC. Future research should aim for larger and more diverse samples, consider the impact of confounding factors, implement longer intervention periods, and use standardised biomarkers for evaluation to overcome these limitations and provide more robust evidence regarding TCC's potential benefits for cancer survivors. Addressing these limitations is critical to firmly defining TCC's involvement in cancer recovery.

The encouraging findings on the positive benefits of Tai Chi Chuan (TCC) and mindfulness-based techniques on cancer survivors have numerous crucial implications for the future. To begin, more investigation into the processes behind these advantages is required. Moreover, understanding the specific physiological and psychological routes through which TCC alters biomarkers and general well-being will give useful information for optimising cancer rehabilitation procedures [40-41]. Second, bigger and more diversified trials are needed to determine the generalizability and long-term effects of TCC in different cancer groups. This allows TCC programmes to be tailored to specific cancer kinds, phases, and unique patient demands. Additionally, the incorporation of TCC and mindfulness practices into cancer care programmes, maybe as a supplementary therapy, should be investigated. Collaborations between oncologists, rehabilitation professionals, and mindfulness teachers can help these practices become part of routine cancer treatment regimens. Finally, it is critical that these results are communicated to healthcare providers and cancer survivors. Raising knowledge about the possible advantages of TCC and mindfulness practises can help people make more educated decisions during their cancer rehabilitation path, thereby enhancing their overall well-being and quality of life [54-58, 70-72].

4. Conclusion

According to the research, biomarkers have a critical role in improving the precision of evaluations in cancer rehabilitation. These biological markers provide objectivity, allowing healthcare providers to track patients' progress and customize interventions to address treatment-related problems as soon as possible. The post presents key studies about the impact of TCC on cancer survivors. The researches demonstrated that TCC practice is linked to stabilizing insulin levels following chemotherapy, which alleviates a frequent concern among cancer survivors. Furthermore, it is obvious that TCC has a net favorable influence on health-related outcomes. Other studies discovered that TCC resulted in substantial improvements in several biomarkers. Notably, TCC increased white and red blood cell counts, indicating possible immune system benefits. Furthermore, TCC patients reported improved hand grip strength and short-term memory, indicating both physical and psychological benefits. TCC also had positive effects on several blood indicators. There were increases in the number of white blood cells, red blood cells, hemoglobin, cortisol (stress), serotonin (pleasure), and high-sensitivity C-reactive protein (inflammation). Along with these biomarker improvements, TCC patients also reported better quality sleep, less stress, more enjoyment, and increased social interaction. Furthermore, TCC improves the psychological outcomes of breast cancer survivors. Enhanced life quality and decreased levels of stress, anxiety, and hopelessness are among these results. Notably, cortisol, a biomarker associated with stress, was assessed in multiple trials; some showed favorable changes, while others showed constant levels in comparison to control groups. These findings highlight the potential of TCC and mindfulness-based practices to improve the psychological well-being of cancer survivors. TCC shows potential in terms of bone metabolic indicators by improving bone density and bone-specific alkaline phosphatase (BAP). However, differences in the effects on different bone-related biomarkers imply that more study is needed to completely understand the precise implications. In terms of quality of life (QoL), TCC appears to have a greater impact on emotional well-being while having no effect on other aspects of total QoL. This emphasizes the significance of TCC as a possible tool for addressing certain components of QoL, notably emotional aspects. TCC may also impact biological indicators, particularly those connected to immunity, according to the research. While certain indicators, such as CD4+ and CD8+ T cells, were unaltered, CD55 cell counts decreased significantly, presumably boosting T-cell immunity. This demonstrates the nuanced interactions between TCC and several biomarkers involved in cellular immunity. Additionally, serotonin and dopamine are two neurotransmitters that are crucial for regulating mood in the context of brain biomarkers, and TCC has been linked to beneficial alterations in their levels. This demonstrates that TCC may be beneficial for emotional health and may lessen the symptoms of mental health illnesses. Furthermore, TCC participants report feeling less worn out than control group participants, which suggests that therapy may help with cancer-related tiredness. To address one of the typical difficulties cancer survivors, confront, this could be extremely helpful. However, it is critical to realize the study's shortcomings, which include small sample numbers, cancer survivor group heterogeneity, short intervention periods, and a lack of well-matched control groups. These limitations highlight the need for more thorough research to fully understand TCC’s advantages in cancer recovery.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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