Formosa Journal of Applied Sciences (FJAS)
Vol. 5, No. 4 2026: 1045-1056

Synergistic Effects of Rice Bran Supplementation and Exercises including Tai Chi on Diabetic Wound Healing: Mechanistic, Physiologic, and Immunologic Insights

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A R T I C L E I N F O

Keywords: Rice Bran, Exercises including Tai Chi, Diabetic Wound Healing, Mechanistic, Physiologic

Received : 18, December
Revised : 20, February
Accepted: 22, April

A B S T R A C T

Diabetic wounds present a significant challenge due to impaired healing processes exacerbated by chronic inflammation and compromised immune responses. A review was conducted using pertinent search phrases and keywords related to rice bran and exercises including Tai Chi. Academic databases such as PubMed and Google Scholar were utilized to find published peer-reviewed research. The multifaceted benefits of rice bran in diabetic wound healing are attributed to its potent antioxidant, anti-inflammatory, and immunomodulatory properties. By reducing oxidative stress, enhancing angiogenesis and collagen synthesis, and modulating the immune response, rice bran offers a promising natural therapeutic strategy for managing diabetic wounds. Exercise, including Tai Chi, provides significant benefits for the management and healing of diabetic wounds through various mechanistic, physiological, and immunological pathways.

INTRODUCTION

Diabetes is a chronic illness that makes it difficult for the body to mend wounds and frequently results in serious consequences. Diabetes-related wounds are particularly difficult to cure because of weakened immune systems and prolonged inflammation that worsen the condition. Diabetes-related wounds provide a substantial therapeutic challenge because of the hampered healing processes, prolonged inflammation, and weakened immune system. The many facets of these difficulties are too complex for current therapy treatments to fully address.

Rice bran, a byproduct of rice milling, is recognized for its health benefits, particularly in Indonesia. This herb contains bioactive compounds that contribute to its physiological and immunologic effects, aiding in the prevention of various health issues Rice bran, rich in bioactive compounds such as tocopherols, tocotrienols, and γ-oryzanol, possesses antioxidant, anti-inflammatory, and immunomodulatory properties that could enhance wound healing outcomes. Rice bran, as an Indonesian herb, offers significant health benefits through its antioxidant, cholesterol-lowering, immune-modulating, and anti-inflammatory properties. These mechanisms make it a valuable dietary component for preventing various health problems.

The results and conclusions of Endin Nokik Stujanna's (2023) study indicate that rice bran can reduce total cholesterol, the LDL/HDL ratio, and boost HDL levels in hypercholesterolemia rats. Further research is required to accurately understand how rice bran decreases total cholesterol, lowers the LDL/HDL ratio, and boosts HDL levels.

Studies on Rice Bran (RB), a nutritional supplement made from whole grain rice that is presently underused, have shown that RB is a rich source of numerous protective bioactive compounds. The capacity of RB to scavenge free radicals and prevent illness has been attributed to the presence of substances such as flavonoids, resveratrol, γ-oryzanol, ferulic acid, policosanol, tocotrienol, derivatives of hydroxycinnamic acid, acylated steryl glucosides and many bioactive peptides. Dietary supplementation of these bioactive compounds has shown benefits in vascular inflammation, endothelial function, hypertension, hyperlipidemia, and hyperglycemia by decreasing free-radical-mediated oxidative stress because of the synergistic actions of numerous RB-derived substances. Although RB has bioactive properties that would enable it to target certain metabolic processes in vitro, variables such as microbiota and bioavailability

Nancy Saji & Associates, 2019 Rice bran is full of polysaccharides and other substances that boost immunity by stimulating natural killer cells and macrophages. As an underlying cause of many chronic illnesses, inflammation can be reduced with the use of rice bran. Exercise's Beneficial Effects on Diabetes Wounds Blood flow is improved with exercise, and this is essential for supplying oxygen and nutrients to wound sites. Improved circulation promotes quicker and more effective recovery. Regular aerobic exercise considerably increases blood flow in diabetes patients, improving wound healing, according to a research by Kim et al. (2020). The immune system, which is strengthened by physical exercise, is essential for preventing infections and promoting the healing of wounds. A study by Munoz et al (2019) . found that exercise-induced enhancements in immune activity may help diabetic wounds be better managed. One of the main obstacles to wound healing in diabetics is chronic inflammation. It has been demonstrated that exercise lowers inflammatory markers. According to a Huang et al. (2018) study, moderate exercise helps the body repair wounds by lowering systemic inflammation.

Tai Chi is a type of mind-body exercise that incorporates deep breathing, meditation, and slow, purposeful motions. It is becoming more well-known due to its possible advantages in treating difficulties brought on by diabetes. Tai chi improves improved wound healing indirectly by lowering stress and enhancing mental health. Tai Chi lowers cortisol levels, a stress hormone that might obstruct the healing process, according to Liu et al. (2021). Regular Tai Chi practice has been linked to improved blood sugar regulation, which is necessary for the healing of wounds. Tai Chi practice significantly lowers HbA1c levels, a measure of long-term blood glucose management, according to research by Chen et al. (2019). Tai chi increases muscular strength and balance, which lowers the chance of additional damage and increases mobility all of which are critical for wound care. Tai Chi practitioners had greater balance and physical function, which improved wound care and self-care, according to research by Wang et al. (2020).

Patients with diabetes who engage in exercises including Tai Chi or other physical activity can see a dramatic improvement in the healing of their wounds. Exercise is a beneficial adjuvant in the care of diabetic wounds because it has the combined benefits of better circulation, decreased inflammation, enhanced immunological function, reduced stress, better glucose control, and improved physical balance. The possible synergistic benefits of supplementing with rice bran and practicing exercises including Tai Chi and other activities as adjuvant therapy for diabetic wound healing are examined in this research, with particular attention paid to their mechanize, physiological, and immunological foundations.

LITERATURE REVIEW

Research on diabetic wound healing continues to evolve, highlighting multimodal approaches that combine nutritional interventions and physical activity. One approach that is gaining attention is rice bran supplementation, which is rich in antioxidants, fiber, and bioactive compounds such as γ-oryzanol and tocopherol, which have been shown to have anti-inflammatory effects and enhance tissue regeneration. Furthermore, physical exercise such as Tai Chi is known to provide physiological benefits by improving blood circulation, controlling glucose levels, and modulating the immune response, which plays a crucial role in the wound healing process. Several studies have shown that the combination of nutritional interventions and exercise can produce a synergistic effect, where improvements in metabolic and immunological conditions accelerate the proliferation and remodeling phases of diabetic wounds. Mechanistically, this synergy involves reduced oxidative stress, increased activity of immune cells such as macrophages, and stimulation of angiogenesis. Therefore, the integration of rice bran supplementation and Tai Chi exercise has the potential to be a comprehensive strategy for improving wound healing effectiveness in diabetic patients, although further research is needed to confirm its mechanisms and broad clinical efficacy.

METHODOLOGY

Doing a comprehensive literature study to assess rice bran involves a number of crucial steps, some of which exercises include Thai Chi for diabetic wounds. The procedures used in gathering, evaluating, and summarizing relevant studies Clearly state the objectives of the study and the parameters of the review. Make a list of relevant search terms and keywords related to rice bran. Some examples of these tasks include Thai chi Make methodical searches in academic databases (like PubMed and Google Scholar) to locate published, peer-reviewed research. Use Boolean operators (AND, OR) to combine search keywords to identify relevant material and enhance search results.

Organize search results by titles and abstracts to locate potentially interesting research. Describe the results of the chosen research, emphasizing rice bran and offering tasks like as Thai Chi for Diabetes Illnesses Determine recurring themes, motifs, and tendencies throughout the literature. Make a qualitative summary of the data, emphasizing important discoveries and areas of agreement or disagreement. When evaluating results, take into account the strength of the evidence and any potential constraints.

RESEARCH RESULT AND DISCUSSION

The Effect of Rice Bran on the Healing of Diabetic Wounds

Millions of people worldwide suffer from diabetes mellitus, a chronic hyperglycemic condition that causes a number of problems, including slowed wound healing. Diabetic wounds are associated with extended healing durations and heightened susceptibility to infections due to ongoing inflammation, compromised angiogenesis, and malfunctioning immunological responses. Conventional wound care techniques require novel treatments that not only facilitate tissue healing but also target underlying immunological and physiological deficits.

The outer layer of the rice grain, known as rice bran, is a byproduct of rice milling and contains a wealth of bioactive components, including ferulic acid, tocopherols, tocotrienols, and phytosterols. Strong antioxidant qualities that scavenge free radicals and lower oxidative stress in the wound microenvironment are exhibited by these constituents, as well as antibacterial qualities that are essential to wound healing. Furthermore, γ-oryzanol has been found to have anti-inflammatory properties, which might potentially lessen the chronic inflammation seen in diabetic wounds.

Rice bran's antioxidant properties are the main way that it promotes wound healing. Diabetes-related hyperglycemia increases the generation of reactive oxygen species (ROS), which results in oxidative stress and hinders the healing process. The antioxidants in rice bran reduce oxidative damage and encourage cellular regeneration by neutralizing ROS. (Brown et al ; 2017, Wang et al ;2018) Tocopherols, tocotrienols, and gamma-oryzanol, which fend off free radicals and shield cells from oxidative damage, are among the many antioxidants found in rice bran. A research project by Zubaidah et al .(2019)

According to Farouk et al. (2019), rice bran extract has been shown to enhance the body's natural defense mechanism against chronic illness by increasing the capacity of antioxidants. Bran Rice Rice bran's high fiber and phytosterol concentration has the potential to reduce cholesterol. By preventing reabsorption from the intestines, it is inhibited from being absorbed. Rice bran extract has been shown in a research by Shafie et al. (2021) to lower inflammatory markers, which may help prevent and treat inflammatory diseases.

Rice bran is full of polysaccharides and other substances that boost immunity by stimulating natural killer cells and macrophages. Rice bran polysaccharides enhance immune responses and boost resistance to infections, according to researched by Wanyo et al. (2020). Rice bran's anti-inflammatory qualities aid in reducing inflammation, which is a major underlying cause of many chronic diseases: Rice bran extract has been shown in research by Shafie et al. (2021) to lower inflammatory markers, which may help prevent and treat inflammatory diseases. Lowering Cholesterol Levels:

Because rice bran has a high fiber content and phytosterols, which prevent cholesterol from being absorbed in the intestines, cholesterol levels are lowered. According to research by Rangkadilok et al. (2018), eating rice bran significantly lowers LDL cholesterol levels, which is good for cardiovascular health. Because of its anti-inflammatory, immune-modulating, cholesterol-lowering, and antioxidant qualities, rice bran is an Indonesian plant with major health advantages. It is a beneficial dietary ingredient for avoiding several health issues because of these methods. A Jain et al. (2020) study The research focuses on how rice bran oil (RBO), in particular its antioxidant qualities, helps diabetic wounds recover. The study showed that by upregulating the production of antioxidant enzymes including superoxide dismutase (SOD) and catalase (CAT), RBO greatly improves wound healing in diabetic rats. These enzymes are essential for reducing oxidative stress, which is a major cause of poor wound healing in diabetes patients.

The study concluded that the antioxidant properties of rice bran oil could promote faster and more effective healing of wounds in diabetic individuals by reducing oxidative stress and enhancing the activity of critical antioxidant enzyme Through the physiological enhancement of angiogenesis and collagen production, rice bran promotes wound healing. The creation of new blood vessels, or angiogenesis, is essential for bringing nutrients and oxygen to the wound site, while the production of collagen gives new tissue its structural support. Ferulic acid produced from rice bran has been demonstrated in a study by Kim et al. (2019) to upregulate VEGF and its receptor VEGFR2, which in turn enhances angiogenesis. Furthermore, it was shown that rice bran oil increased the amount of collagen that was deposited in the wound bed, which improved wound closure and the tensile strength of the newly created tissue.

Immunologically, rice bran exerts significant effects on the inflammatory response, a critical phase in wound healing. In diabetic wounds, the inflammatory phase is often prolonged and dysregulated, leading to chronic inflammation and delayed healing.

By reducing pro-inflammatory cytokines and increasing anti-inflammatory mediators, rice bran influences the immune response. According to research by Liu et al. (2021), in diabetic mice, rice bran extract increases the levels of anti-inflammatory cytokines like IL-10 while lowering the levels of pro-inflammatory cytokines like TNF-α and IL-6. This immunomodulatory effect helps resolve inflammation more effectively, transitioning the wound from the inflammatory phase to the proliferative phase more efficiently in diabetic wound healing. The researchers found that rice bran extract significantly modulates the levels of key inflammatory cytokines, which are crucial for wound healing processes in diabetic conditions, thereby promoting more effective wound recovery

Furthermore, rice bran has an immunological effect that goes beyond improving macrophage performance. Macrophages are involved in both inflammation and tissue repair during the course of wound healing. According to research by Zhang et al. (2022), components of rice bran, in particular tocotrienols, have been found to support macrophage polarization from the pro-inflammatory M1 phenotype to the anti-inflammatory M2 phenotype.

This shift accelerates the healing process by reducing inflammatory damage and promoting tissue regeneration.in managing diabetic wounds. The multifaceted benefits of rice bran in diabetic wound healing are attributed to its potent antioxidant, anti-inflammatory, and immunomodulatory properties. By reducing oxidative stress, enhancing angiogenesis and collagen synthesis, and modulating the immune response, rice bran offers a promising natural therapeutic strategy for managing diabetic wounds. To fully realize rice bran's potential and turn these discoveries into diabetic therapies that work for patients, more investigation and clinical testing are required.

Mechanistic, Physiological, and Immunological Effects of Exercises including Tai Chi on Diabetes-Related Wounds:

a. Enhanced Blood Flow and Circulation
   Blood circulation is improved by exercise, and this is essential for efficient wound healing. Increased blood flow guarantees that the wound site receives a greater supply of vital nutrients and oxygen, which promotes tissue regeneration and healing. Blood flow is improved with exercise, and this is essential for supplying oxygen and nutrients to wound sites. Improved circulation promotes quicker and more effective recovery. Regular aerobic exercise considerably increases blood flow in diabetes patients, improving wound healing, according to research by Kim et al. (2020). Frequent exercise has been demonstrated to enhance wound-healing processes in diabetes patients by improving endothelial function and increasing capillary density (Yang et al., 2021; Zhang et al., 2022 Chen et al., 2020). The immune system, which includes neutrophils and macrophages, is strengthened by physical exercise. These cells are essential for the first stage of wound healing, as well as for preventing infections and promoting wound healing. thereby enhancing the removal of bacteria and dead cells from the area of the wound. Meaning that improved immune activity brought on by exercise may result in better diabetic wound care.
b. Kim et al. (2021) Munoz et al. (2019), Huang et al. (2018)
   Exercise strengthens the body's defenses against oxidative stress, which can hinder the healing of wounds. Exercise increases the levels of endogenous antioxidants, such as superoxide dismutase (SOD), which shield tissues from oxidative damage, according to research by Munoz et al. (2020). Tai Chi is a mind-body exercise that incorporates deep breathing, meditation, and slow, purposeful motions. It is becoming more well-known due to its possible advantages in treating difficulties brought on by diabetes.

Physical activity stimulates collagen production, a critical component of wound healing. Wang et al. (2021) showed that Tai Chi practice increases the expression of collagen genes, contributing to stronger and more resilient wound tissue. Exercise reduces hyperglycemia-induced damage, supporting better wound healing. Liu et al. (2019) demonstrated that Tai Chi improves HbA1c levels, thereby reducing glucose toxicity in wound tissues. Tai Chi, a low-impact, moderate-intensity exercise, integrates aerobic and anaerobic movements. It enhances microcirculation and reduces blood glucose levels, critical factors in managing diabetic wounds. The slow and controlled movements of Tai Chi promote peripheral circulation, improving oxygen and nutrient delivery to tissues, thus facilitating wound healing (Chen et al., 2019) .

Tai chi improves improved wound healing indirectly by lowering stress and enhancing mental health. Tai Chi lowers cortisol levels, a stress hormone that might obstruct the healing process, according to Liu et al. (2021). Tai chi increases muscular strength and balance, which lowers the chance of additional damage and increases mobility—all of which are critical for wound care. Tai Chi practitioners had greater balance and physical function, which improved wound care and self-care, according to research by Wang et al. (2020).

Reduction of Hyperglycemia

Regular exercise is crucial for managing blood glucose levels. Hyperglycemia impairs wound healing by causing glycation of proteins, disrupting cellular function, and slowing down the healing process. Exercise-induced improvements in insulin sensitivity help lower blood glucose levels, thus reducing the detrimental effects of hyperglycemia on wound healing (Miyamoto et al., 2020) .

Enhanced Angiogenesis

The creation of new blood vessels, or angiogenesis, is facilitated by physical exercise by upregulating vascular endothelial growth factor (VEGF). Patients with diabetes should pay special attention to this as their weakened angiogenic response might impede the healing of wounds. It has been demonstrated that Tai Chi and aerobic exercise both raise VEGF levels, which in turn enhances the angiogenic process and promotes wound healing (Li et al., 2019; Sun et al., 2020).

Modulation of the Inflammatory Response: Physical activity has a significant impact on the immune system, especially when it comes to regulating the inflammatory response, which is essential for the healing of wounds. Diabetic wounds are characterized by chronic inflammation, which prolongs the healing process. Exercise promotes a more balanced inflammatory response favorable to wound healing by reducing pro-inflammatory indicators like TNF-α and IL-6 and triggering the production of anti-inflammatory cytokines (Wang et al., 2021; Liu et al., 2020). Huang et al. (2019)

Macrophage Polarization: According to recent research, physical activity has an impact on macrophage polarization. Macrophages can take on an anti-inflammatory (M2) or pro-inflammatory (M1) character when it comes to wound healing. Tai chi is one sort of exercise that has been demonstrated to encourage macrophage polarization towards the M2 phenotype, which is linked to tissue regeneration and repair. This change aids in the healing of diabetic wounds by reducing inflammation and promoting tissue repair (Zhu et al., 2019; Chen et al., 2021).

Exercise, including Tai Chi, offers significant benefits for the management and healing of diabetic wounds through various mechanistic, physiological, and immunological pathways. Exercise plays a multifaceted role in promoting wound healing by improving blood flow, reducing hyperglycemia, enhancing angiogenesis, and modulating the immune response. These findings underscore the importance of incorporating structured physical activity into the therapeutic regimen for diabetic patients to improve wound healing outcomes.

Resume

Antioxidants including γ-oryzanol, tocopherols, and tocotrienols, which are abundant in rice bran, reduce oxidative stress, a significant barrier to diabetic wound healing. Chou et al. (2021) report that rice bran's antioxidant qualities considerably lower reactive oxygen species (ROS) in wound tissues, accelerating the healing process. Rice bran's anti-inflammatory properties help it to heal wounds. Rice bran extract inhibits pro-inflammatory cytokines such TNF-α and IL-6, which are elevated in diabetic wounds (Chen et al., 2019). Exercises including Tai Chi improve peripheral blood flow, which is important for supplying nutrients and oxygen to the area where a wound is located. According to a Li et al. (2020) study, practicing Tai Chi helps diabetes patients' microcirculatory function, which helps with wound healing

CONCLUSIONS AND RECOMMENDATIONS

Combining rice bran supplementation with Exercises including Tai Chi offers a comprehensive approach to diabetic wound healing. When combined with Tai Chi's enhanced circulation and glycemic management, rice bran's anti-inflammatory and antioxidant qualities provide a synergistic environment that promotes wound healing. Furthermore, the combined effectiveness of these therapies is further enhanced by their ability to influence immunological responses. The integration of rice bran supplementation and Exercises including Tai Chi exercises presents a promising strategy for improving diabetic wound healing through mechanistic, physiologic, and immunologic interactions.

ADVANCED RESEARCH

Future research should focus on clinical trials to optimize these interventions and further elucidate their synergistic effects on diabetic wound healing.

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