

A Comprehensive Review of Traditional Chinese Medicine Applications in Marathon Fatigue Recovery Period

Tan Liang¹, Wu Jianwei², Yang Qunru^{1,*}

¹*School of Sports and Health, Chengdu University of Traditional Chinese Medicine, Chengdu, Sichuan, China*

²*School of Chinese Classics, Chengdu University of Traditional Chinese Medicine, Chengdu, Sichuan, China*

**Corresponding author*

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Abstract: With the global proliferation of marathon running, post-exercise fatigue exerts a pronounced impact on athletes' health and performance. Fatigue manifests not only as muscular strength decline but also encompasses psychological weariness and physiological function impairment. Traditional Chinese medicine (TCM), owing to its unique therapeutic modalities and comprehensive regulatory mechanisms, demonstrates advantages in the rehabilitation treatment of exercise fatigue. This paper, through a review of the mechanisms of marathon-induced fatigue and the application of TCM during the recovery period, discerns that TCM methods such as herbal decoctions, acupuncture, tuina massage, and guided exercises effectively modulate the balance of qi, blood, yin, and yang, promoting comprehensive recovery. Studies indicate that TCM plays a positive role in enhancing psychological resilience, boosting immunity, and balancing the endocrine system, yet its mechanisms warrant further exploration. This study aims to provide a novel perspective in the field of sports medicine and propel the integration of traditional Chinese and Western medicine while proposing future research directions.

In light of its challenging nature and widespread popularity, marathon running has burgeoned into a globally cherished athletic pursuit. Statistics reveal that in the year preceding the COVID-19 pandemic, nearly 5.83 million individuals in China participated in 1,828 marathon events. Despite the crosscurrents of the H1N1 influenza and COVID-19 viruses, the year 2023 witnessed a participation of 6.0519 million individuals across 699 events, with projections indicating a continued surge in both participant numbers and event frequencies for the year 2024. As the participant pool expands, post-exercise fatigue concerns have progressively surfaced, impacting not only professional athletes but also a vast cohort of fitness enthusiasts. Traditional Chinese medicine (TCM), as a pivotal component of China's traditional medical heritage, has gradually garnered attention for its application in the realm of exercise fatigue recovery. Despite TCM's provision of comprehensive and personalized rehabilitation methodologies, pertinent research and clinical

applications remain in their nascent stages. This paper reviews the current status and prospects of TCM in treating marathon-induced fatigue, aiming to deepen understanding of TCM's role in sports rehabilitation and offer athletes a more diversified array of recovery options.

1. Marathon Fatigue Mechanisms

Marathon running entails a high-intensity, prolonged endurance activity, during which participants inevitably experience fatigue. The term "fatigue" in traditional Chinese medicine (TCM) literature dates back to the "Synopsis of Golden Chamber: Treating Deficiency Diseases" in the Four Classics of TCM: "Weak bones and muscles, profuse sweating due to fatigue, lying still without movement, and slight breeze under the covers, thereby leading to it." The "fatigue" and "exhaustion" depicted therein bear semblance to modern perceptions of exercise fatigue. The following elucidation delineates the etiology of exercise fatigue from both TCM pathomechanistic and contemporary medical perspectives.

1.1 TCM Pathomechanisms of Exercise Fatigue

According to TCM theory, exercise-induced fatigue manifests diversely as qi deficiency, blood deficiency, yang deficiency, yin deficiency, phlegm dampness, among others, all primarily attributed to visceral functional disharmony. Specifically, exercise fatigue may arise from spleen-kidney weakness, qi-blood insufficiency, and liver-lung impairment. The spleen, governing postnatal essence and transportation, and the kidneys, housing prenatal essence, when weakened, lead to qi-blood deficiency and subsequent fatigue. Qi serves as the impetus for vital activities, while blood forms their material foundation; their insufficiency results in inadequate nourishment of organs, meridians, and collaterals, culminating in fatigue. The liver regulates dispersal and the smooth flow of qi, while the lungs govern dissemination and descent, playing roles in respiration. Damage to the liver and lungs impairs systemic qi regulation, exacerbating fatigue. Marathon-induced fatigue in TCM can be understood as the confluence of qi-blood deficiency, spleen-stomach dysfunction, kidney essence depletion, and spirit impairment. Consequently, in treatment and rehabilitation, TCM methodologies should holistically address these factors to achieve comprehensive bodily recovery and regulation.

1.2 Contemporary Medical Perspectives on Marathon Fatigue Mechanisms

Contemporary medical perspectives on marathon-induced fatigue delineate a multifaceted interplay of multiple systems. Prolonged, high-intensity exercise disrupts energy metabolism, leading to glycogen depletion and lactate accumulation, culminating in muscle fatigue. Simultaneously, central nervous system inhibition and decreased efficiency of neural impulse transmission exacerbate muscle strength decline. Prolonged high-intensity workload on the cardiovascular system induces myocardial fatigue and diminished cardiac function, impeding blood circulation efficiency. Additionally, although the stress response of the endocrine system aids in short-term exercise challenges, prolonged stress induces hormone imbalances, hastening fatigue onset. Hence, marathon-induced fatigue results from the collective interplay of energy metabolism, the nervous system, the cardiovascular system, and the endocrine system. Future research should delve deeper into the interactions among these systems and the influence of individual differences on fatigue mechanisms to guide the formulation of more precise anti-fatigue strategies.

2. Application Status of Traditional Chinese Medicine in Combating Exercise Fatigue Recovery Field

The practical application of Traditional Chinese Medicine (TCM) in combating exercise fatigue recovery predominantly encompasses Chinese herbal formulas, acupuncture, tuina massage, and guided exercises, all of which play pivotal roles in the recovery phase of marathon-induced fatigue.

2.1 Chinese Herbal Formulas

Chinese herbal formulas constitute a significant component of TCM therapy against exercise fatigue. During the recovery period from marathon-induced fatigue, Chinese herbal formulas exert synergistic effects by invigorating the liver and spleen, boosting yang and qi, nourishing yin and blood, and tonifying the kidneys and warming yang, thus regulating the body's yin-yang balance, promoting blood circulation, accelerating the metabolism of fatigue substances, alleviating fatigue symptoms, and enhancing bodily recovery capabilities. Currently employed anti-fatigue formulas include Buzhong Yiqi Tang, Si Junzi Tang, Huang Maosheng Mai Yin, Huang Maosheng Jian Zhong Tang, Jin Gui Shen Qi Wan, Buqi Huoxue Fang, Liqi Tiaobu Tang, Shengyang Yige Tang, among others. Buzhong Yiqi Tang can boost yang and qi, regulate spleen-stomach function^[1], enhance the activities of serum glutathione peroxidase and serum superoxide dismutase, decrease malondialdehyde content, thus enhancing the body's anti-fatigue capabilities^[2]. Si Junzi Tang, a classic qi and blood tonic formula, significantly inhibits the elevation of blood lactate and lactate dehydrogenase induced by exhaustive exercise, as well as suppresses the decline in liver and muscle glycogen levels, prolongs the swimming time of mice under load, and improves their endurance and capacity, demonstrating its anti-fatigue effects^[3-4].

2.2 Acupuncture Treatment

Acupuncture treatment is widely employed during the recovery phase of exercise-induced fatigue. By stimulating the body's meridians and acupoints, acupuncture regulates the functions of the nervous and endocrine systems, alleviates post-exercise fatigue, and promotes bodily recovery. Hu Linghui's^[5] controlled trials indicate that exercise-induced fatigue can inhibit motor cortex excitability, and acupuncture intervention can ameliorate the reduced excitability of the motor cortex caused by fatigue, promote the increase in motor evoked potential (MEP) amplitude, shorten MEP latency, and facilitate heart rate recovery, playing a crucial role in fatigue recovery. Xu Huiqian's^[6] research demonstrates that moxibustion can promote the expression of p300 and CBP in myocardial cells after exercise fatigue, inhibit the initiation of cell apoptosis process, thus reducing the apoptosis of myocardial cells after intense exercise and protecting heart function. Xu Xiaoshan et al.^[7] found that moxibustion treatment with herb cake on CFS rats can regulate serum BLA, CXCL9, and β -EP levels, and activate the AMPK/PGC-1 α signaling pathway, thereby improving the body's oxidative stress status and maintaining relative energy metabolism balance.

2.3 Tuina Massage Therapy

Through the techniques of tuina massage, muscle tension and fatigue can be relieved, blood circulation can be improved, fatigue substances can be metabolized more quickly, and the body's recovery speed can be enhanced. Wang Chen's^[8] research indicates that tuina massage rapidly alleviates post-exercise fatigue by relaxing muscles. Miao Jing et al.^[9] studied the efficacy of acupuncture combined with tuina massage in combating exercise-induced fatigue, and the results showed that acupuncture at Shenshu and Chengshan acupoints combined with tuina massage or

tuina massage alone can reduce serum lactate, lactate dehydrogenase, creatine kinase, blood urea nitrogen, and blood ammonia levels, thus relieving fatigue. However, the efficacy of acupuncture combined with tuina massage in alleviating exercise-induced fatigue is more evident. Niu Yan et al.^[10] studied how tuina massage improved the immune-inflammatory state of peripheral blood in EF rats, demonstrating the effects of anti-inflammatory, anti-apoptotic, and immunomodulatory techniques.

2.4 Guided Traditional Chinese Medicine Techniques

Guided traditional Chinese medicine techniques, such as the Eight Section Brocade, Five Animal Frolics, Tai Chi, and Six Character Formula, have become important means of combating exercise-induced fatigue. Unlike drug ingestion, which may pose risks such as drug allergies, drug dependence, or even contain banned substances, or acupuncture and massage techniques, which require high skill levels from the practitioner, guided techniques are less susceptible to external interference, safe, and effective, warranting advocacy. Sun Kaiwen^[11] believes that long-term practice of the Eight Section Brocade can enhance immunity and muscle strength and alleviate exercise-induced fatigue. Yu Lulu's^[12] study found that the use of the Eight Section Brocade can accelerate the recovery of fatigue in female college basketball players after teaching. Xie Hui^[13] believes that the efficacy of the Five Animal Frolics in alleviating exercise-induced psychological fatigue is significant.

2.5 Introduction of a Novel Anti-Fatigue Theory—Chronopharmacological Formulas

Chronopharmacological formulas represent a novel anti-fatigue theory that has garnered widespread attention and application in research on Chinese herbal formulas against exercise-induced fatigue. Based on the research by Zhao Xuanmin^[14] and the research progress by Fu Zhibin and Tang Xiaomei^[15], the introduction of chronopharmacological formulas aims to address the issues during the recovery phase of marathon-induced fatigue. The key idea of chronopharmacological formulas lies in adjusting the use and dosage of Chinese herbal formulas according to the passage of time and the evolution of the condition, precisely calculating the degree of fatigue and related symptoms at each time point, and devising personalized treatment plans for athletes. Through considering the differences at different time points, chronopharmacological formulas can better combat the symptoms during the recovery phase of marathon-induced fatigue.

A review of TCM research on combating exercise-induced fatigue mentions^[16] that chronopharmacological formulas mainly include four steps: establishing a problem model, data collection and analysis, drug selection and adjustment, and efficacy evaluation. Firstly, a mathematical model describing the degree of athlete fatigue and related symptoms needs to be established to quantitatively evaluate the condition. Then, by collecting and analyzing physiological indicators and subjective feelings of athletes at different time points, accurate data can be obtained to guide treatment. Based on individual differences and disease progression, the most suitable herbal formulas are selected and their dosages adjusted using TCM theory and experience. Finally, through long-term observation and efficacy evaluation, treatment plans can be continuously improved and optimized.

3. Deficiencies and Prospects of Traditional Chinese Medicine in Combatting Exercise-Induced Fatigue Recovery

3.1 Shortcomings

While Traditional Chinese Medicine (TCM) has achieved certain effectiveness in the recovery from exercise-induced fatigue, numerous issues and deficiencies still exist. Firstly, there is a lack of large-scale, high-quality clinical research to support its efficacy, leading to insufficient evidence. Secondly, there are prominent issues regarding the standardization and normalization of TCM, with significant individual differences in treatment plans, posing challenges to practical application. Lastly, the mechanisms of TCM in the recovery from exercise-induced fatigue are not fully understood, requiring further in-depth research to provide scientific theoretical support. These problems and deficiencies constrain the application and development of TCM in the recovery from exercise-induced fatigue.

3.2 Future Prospects

Through comprehensive research, we have found that TCM has potential efficacy in the recovery phase of marathon-induced fatigue. TCM can alleviate fatigue symptoms, promote recovery, and enhance training capacity. As a unique medical system, TCM emphasizes holistic regulation, balance, and harmony, integrating with Western rehabilitation concepts to provide comprehensive rehabilitation services for marathon runners. By combining TCM theory with modern rehabilitation methods, we can better meet the individualized needs of athletes during the recovery phase and improve rehabilitation outcomes. Future research can be expanded in several aspects: Firstly, more sports rehabilitation practices can be combined to summarize the specific application effects and indications of different TCM therapies in the recovery phase of marathon-induced fatigue. Secondly, in-depth research can be conducted into the mechanisms of TCM in the recovery phase of marathon-induced fatigue, exploring possible biological and physiological bases. Additionally, long-term tracking studies can be conducted, utilizing big data as a medium to assess the effects of TCM on marathon runners in long-term recovery and sustained training.

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