Prevention and Rehabilitation Strategies for Common Sports Injuries in Marathon

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Abstract. With the rapid development of the social economy and the rapid improvement of public health and sports awareness, marathon sports continue to flourish. As a competitive activity that challenges the limits of human endurance, it requires extremely high physical and mental qualities. However, with high-intensity, long-term, and repetitive mechanical loads, runners face an undeniable risk of sports injuries. This article systematically summarizes the causes, prevention strategies, and scientific rehabilitation pathways of common marathon injuries such as iliotibial band syndrome, patellofemoral joint pain syndrome, Achilles tendinitis, ankle sprains, muscle strains, and muscle spasms, such as physical therapy and functional recovery training. Intended to provide systematic injury prevention and rehabilitation guidance for runners, coaches, and medical workers, and to support the healthy and sustainable development of marathon sports. Only by deeply understanding the damage mechanism and implementing comprehensive management strategies can we effectively reduce risks, ensure the health of runners, and ultimately promote the vigorous development of marathon sports towards a safer, more sustainable, and healthier direction, achieving its true sustainable development goals.

Keywords: Marathon, Sports injury, Prevention and Rehabilitation.

1. Introduction

The marathon originated from the Battle of Marathon during the Greco-Persian War in 490 BC. To commemorate the remarkable long-distance run of the Greek messenger Pheidippides during the war, the inaugural modern Olympic Games in 1896 introduced the "Marathon" event, with its core race distance of 42.195 kilometers being retained to this day [1,2]. Presently, the marathon, as an extremely challenging endurance sport, has witnessed explosive growth globally in recent years. According to statistics from the official China Marathon website, there will be 671 marathon events nationwide in 2024, attracting approximately 6.56 million participants. The event categories have evolved into a comprehensive system encompassing full marathons, half marathons, 10K races, 5K races, and family fun runs, catering to the needs of diverse participants ranging from professional runners to casual enthusiasts.

Marathon require extremely high physical fitness from athletes. Long term, high-intensity training and competition expose athletes to a higher risk of sports injuries, such as lower limb injuries, muscle ligament strains, muscle spasms, etc. A randomized controlled trial showed that the incidence of marathon related sports injuries ranged from 8.9% to 48.5% [3]. These injuries may not only prevent athletes from participating in training and competitions in the short term, but long-term repeated injuries may also lead to chronic pain, accelerated joint degeneration, and even end their sports career.

A deep understanding of the epidemiological characteristics and injury mechanisms of common marathon injuries, and the development of scientific and systematic prevention and rehabilitation strategies based on this, has become an important topic in the fields of sports medicine, rehabilitation science, and training. This article aims to integrate current research results and clinical practice experience to provide evidence-based guidance for marathon runners, enthusiasts, coaches, and rehabilitation workers, in order to reduce the incidence of injuries, optimize rehabilitation outcomes, and ultimately ensure the health of runners and improve athletic performance.

2. Common Types of Sports Injuries Sustained in Marathons

2.1. Iliotibial Band Syndrome

The iliotibial tract is an important connective tissue band on the outer thigh of the human body (composed of dense fibrous connective tissue), rather than muscles. It originates from the pelvis and extends downwards to the calf, serving as a crucial structure for maintaining lower limb stability and motor function. At present, most opinions believe that in marathon sports, long-distance runners, due to repeated and high-intensity knee flexion and extension exercises, can cause continuous friction between the iliotibial tract and the lateral femoral condyle, leading to acute and chronic damage to the iliotibial tract, sterile inflammation, and ultimately iliotibial tract syndrome, which is a typical disease that troubles runners (especially long-distance runners). Patients often present with pain on the lateral side of the knee joint (most pronounced when the knee joint is flexed at 20-30°or extended), local bloating, which worsens during running, with or without symptoms such as knee joint weakness, thereby affecting normal life [4].

2.2. Patellofemoral Pain Syndrome

The patellofemoral joint is composed of the patella and femoral condyle, with the patella serving as a lever to increase the instantaneous force arm of the patellofemoral joint, quadriceps femoris, and patellar tendon. Research has found that when the knee joint is flexed 20 degrees, the patella begins to make contact with the femoral condyle. As the flexion angle increases, the contact becomes denser and the contact area reaches its maximum when the knee joint is flexed 90 degrees. Patellofemoral joint pain syndrome is a common injury during running or marathon running, caused by repeated wear and tear of the patellofemoral joint surface during running, especially long-distance running, manifested as knee joint pain, which may or may not be accompanied by cartilage lesions. The pathogenesis is complex, and the core reason is the imbalance of muscle strength around the patellofemoral joint, which leads to abnormal patellar movement trajectory during knee flexion and extension. The etiology involves anatomical structural factors (internal) and external factors. Typical clinical manifestations include pain behind or around the patella, joint stiffness; Pain occurs intermittently and gradually worsens with increasing physical activity, especially after physical activity [4,5].

2.3. Achilles Tendonitis

The Achilles tendon is the most powerful tendon in the human body, serving as a crucial structure connecting the heel and plantar flexor muscles. It mainly transmits the strength of the triceps muscle during exercise and is also the key to effectively storing and releasing force and energy during running and jumping in the lower limbs. Marathon events belong to ultra long running events, and the Achilles tendon and its surrounding tendon sheath may be damaged due to excessive use. If not cured in time, it can also trigger Achilles tendon rupture. A clinical study recruited 84 amateur half marathon athletes (168 feet). All participants underwent bipedal MRI examination and were graded for foot pain using the Foot and Ankle Injury Scale (FASS). Analyze the MRI features related to foot pain in amateur half marathon athletes. The research results found that a high proportion of amateur half marathon athletes in Beijing have painful foot symptoms (122/168), and MRI findings mainly include Achilles tendinitis and plantar fasciitis, which account for approximately 59.5% of all cases [6].

2.4. Ankle Sprain

When marathon runners use insufficient force, they can cause ankle sprains, mild cases of local soft tissue contusions, severe cases of ligament tears (especially the lateral ligament), cartilage injuries, fractures, and dislocations. After injury, rapid pain and swelling of the twisted area, as well as skin bruising, may occur. In severe cases, the affected side may be unable to move due to pain and swelling.

2.5. Muscle Spasms/Strains

Marathon races require participants to complete a prolonged amount of work output. During this process, the hip joint, knee joint, and ankle joint will bear long-term pressure, which can easily lead to exercise fatigue, causing continuous stretching of lower limb skeletal muscles, resulting in muscle spasms and muscle strains caused by exercise fatigue, and even muscle tearing and bleeding. Muscle spasm, also known as cramping, is a spontaneous and rigid contraction of muscles. Muscle fatigue, uncoordinated movements, and cold stimulation during marathon exercise can all lead to muscle spasms, with muscle spasms occurring most commonly in the calves and toes. The pain during the attack is intense, lasting only a few seconds to minutes, but the pain may last for a longer period of time.

3. Preventive Strategies for Sports Injuries

In order to avoid sports injuries caused by marathon sports, athletes are first required to gradually and scientifically arrange training content and load in the daily training, so that marathon training competitions can be conducted scientifically and effectively. Strengthen the standardization of technical movements to avoid sports injuries caused by incorrect technical movements of athletes. Strengthen regular physical training to provide participants with ample physical support for the competition, thereby avoiding sports injuries caused by physical exhaustion.

In addition, it is important to do sufficient preparation activities before the competition to keep your body in the best condition before participating in the competition. Before the competition, it is also important to conduct a physical examination of the participating population, especially the evaluation of their cardiovascular function. During the competition, it is particularly important to maintain an appropriate frequency of drinking water and electrolyte supplementation to avoid the effects of dehydration, hyponatremia, and other factors on physical function. After the race, it is important to engage in low-intensity relaxation running and static stretching in a timely manner to help athletes eliminate metabolic waste and relieve muscle soreness. At the same time, ice compress or cold water bath can reduce inflammation and micro damage, and accelerate muscle recovery [7].

As a unique functional equipment in marathon sports, running shoes should meet the comfort and potential injury prevention needs of runners from both internal and external biomechanical perspectives. Research has shown that under specific running conditions, for every 100g increase in the weight of running shoes, the running time for a distance of 3000 meters will increase by 0 78%, which means that the lighter the running shoes, the higher the running efficiency [8]. Different arch types and gait characteristics have different requirements for sole support, cushioning performance, and shoe design. Running shoes should be selected based on individual foot shape and running habits, and regularly replaced to avoid increased foot pressure and the risk of sports injuries caused by excessive wear and tear

In order to identify exercise risks and risk factors more accurately at an early stage and reduce the occurrence of sports injuries during exercise, scientists are constantly seeking updated technologies, data platforms, and therapies to help runners achieve better exercise results while reducing the risk of injury. For example, smart wearable devices can monitor various physiological parameters of the human body in real time during exercise, providing the possibility for accurate warning and timely intervention of sports injury risk factors. Simultaneously utilizing machine learning models to monitor internal and external workloads from wearable sensor data has clinical utility in assessing the risk of athletes repeatedly overuse soft tissue injuries [9].

4. Rehabilitation Strategies for Sports Injuries

The treatment of sports injuries in marathon events, like other sports injuries, involves both clinical treatment and rehabilitation and functional training. Timely intervention of various rehabilitation methods can help the body improve its adaptability to injuries and restore functional levels as soon

as possible, achieving twice the result with half the effort. The earlier the rehabilitation intervention, the better the treatment effect and the faster the health recovery. Therefore, in order to restore normal function after injury, early comprehensive rehabilitation treatment must be implemented.

4.1. Acute Phase Management

For the treatment of acute phase, such as muscle strains, muscle spasms, etc., the PRICE principle should be followed. Protection: immediately stop the activity that causes pain, and if necessary, use braces, protective gear, or crutches to protect the injured area and prevent secondary injury; Rest: give the injured tissue sufficient rest time to initiate the healing process. Avoid all activities that worsen pain, but engage in gentle activities within the painless range; Ice pack: during the acute phase (usually within 48-72 hours), apply an ice pack to the affected area (be careful to wrap it with a thin towel to avoid frostbite), 15-20 minutes each time, and once every 2-3 hours. Helps alleviate pain, swelling, and inflammatory reactions; Compression: using an elastic bandage to apply moderate pressure from the distal end to the proximal end to wrap the affected area can help control swelling. Pay attention to observing the blood flow (color, temperature, sensation) at the end of the limbs to avoid tightness; Elevation: Raise the injured limb to or above the level of the heart, especially during rest, using gravity to promote blood and lymphatic reflux and reduce swelling.

4.2. Physical Therapy

Manual therapy, such as massage and joint traction, directly improves tissue elasticity and joint range of motion through physical manipulation. For common marathon injuries such as iliotibial band syndrome, the use of deep tissue massage and fascial release techniques can effectively alleviate pain caused by tension in the iliotibial band and reduce local inflammation. A randomized controlled study was conducted on 90 patients with iliotibial tract syndrome, who were randomly divided into an ultrasound group (ultrasound-guided needle knife tendon release surgery), a release surgery group (simple needle knife tendon release surgery), and a control group (local pain point blockade treatment), with 30 cases in each group. Observe the Visual Analog Scale (VAS), Lower Limb Function Scale (LEFS), and Self Rating Anxiety Scale (SAS) of patients in different groups. The results showed that after 2 weeks, 4 weeks, and 6 weeks of treatment, the VAS and SAS scores of all three groups decreased compared to before treatment, and the ultrasound group was lower than the loosening surgery group and the control group, and the loosening surgery group was lower than the control group; After 2, 4, and 6 weeks of treatment, the LEFS scores of all three groups increased compared to before treatment, and the ultrasound group was higher than the loosening surgery group and the control group, while the loosening surgery group was higher than the control group. In addition, the recurrence rate of the ultrasound group was lower than that of the control group. This indicates that it has good therapeutic effects, helps patients relieve pain, improve lower limb function and anxiety, and has good safety [10].

Intelligent therapy devices provide effective support for marathon runners to promote tissue and functional recovery through their diverse technological means. Electrical stimulation therapy is a commonly used technique that can stimulate muscle contraction through low-frequency electrical currents, thereby improving local blood circulation, reducing muscle tension, and relieving pain. It is widely used in the treatment of soft tissue injuries. Cold therapy, also known as cryotherapy, is a method of using specific substances or physical media to absorb heat from the body, reduce the temperature of the contact area and adjacent tissues, and thus achieve therapeutic effects. A study has found that after using cold therapy, the polarization state of macrophages changes, and the proportion of M2 macrophages increases, which helps promote tissue repair and regeneration. Cold therapy can effectively reduce the release of inflammatory factors by regulating the activity of macrophages, thereby alleviating muscle strains, tendon lesions, and accelerating healing [11].

Previous studies have shown that pulse magnetic combined with low-temperature shock analgesia is effective in treating acute ankle sprains, significantly shortening rehabilitation time, reducing pain

and swelling, and restoring joint function. Further exploration is needed regarding its application among marathon athletes.

4.3. Functional Rehabilitation Training

Functional rehabilitation training generally refers to the use of exercise therapy to train the motor function of individuals with disabilities, such as upper or lower limb motor function training, which improves physical function through active or passive movements. Core muscle training is a key component in improving running posture and preventing injuries. A stable core muscle group can not only maintain the balance of the athlete's trunk, but also reduce the burden on the lower limbs, thereby reducing the risk of sports injuries. In addition, the combination of strength training and action mode training is equally indispensable

A systematic review of 13 studies (n=201) was conducted to evaluate the impact of conservative treatment of iliotibial band syndrome on pain and function in runners. The results indicate that hip abductor muscle strengthening training (HAS) is the cornerstone of treatment, with 60% of combination therapy strategies using it as the primary intervention; Combination therapy (such as HAS+shock wave/manual therapy) is more effective than single therapy, with an average pain reduction of 71% (61% for single therapy) and significant improvement in function; The combination of shock wave and HAS has the fastest onset of action (within 4 weeks, the effect is better than the 6-week plan of ultrasound combined with HAS+stretching); Manual therapy (such as myofascial release) combined with HAS can further enhance efficacy; Gait training, as an emerging strategy, has the potential for pain relief and functional improvement in the short term (4-6 weeks), but the evidence is still limited (only 3 small sample studies) [12].

A clinical study included 45 patients with patellofemoral pain syndrome, who were divided into an observation group (22 cases, targeted medial thigh muscle strengthening training and iliotibial tract stretching intervention) and a control group (23 cases, conventional symptomatic rehabilitation treatment) according to the order of their visit time. After 6 weeks of treatment, the VAS scores of both groups of patients were lower than before treatment ($p<0.05$), and the effect of the observation group was better than that of the control group (1.35 vs. 1.75); Similar effects were found in the Lysholm Knee Scoring Scale (LKSS) scores. Indicating that targeted medial thigh muscle strengthening training and iliotibial tract stretching have significant effects on patients with patellofemoral pain syndrome, bringing greater immediate improvements in pain and mobility disorders, and more significant improvements in patients' daily living abilities [13].

The compression of tendons during the rehabilitation process of Achilles tendon disease may be a key factor leading to rehabilitation failure. This discovery provides important clues for improving rehabilitation strategies, so some scholars have broken through the limitations of traditional rehabilitation and proposed the suppression and compression rehabilitation method. The latest study included 42 exercise participants with heel tendon pain for over 3 months, who were randomly divided into two groups. The Restricted Compression Group (LTCR) received a rehabilitation program to avoid tendon compression, while the Traditional Training Group (HTCR) maintained traditional rehabilitation training. All participants received 12-24 weeks of rehabilitation training and underwent systematic tracking and evaluation. The results showed that the pain improvement in the restricted compression group was more than twice that of the traditional group after 3 months; In the assessment of athletic ability, the restricted compression group improved by nearly 30 points (out of 100), while the traditional group only improved by 19 points.

5. Conclusion

Against the backdrop of the deepening of the "Healthy China" strategy and the significant improvement of national living standards, marathon sports have shown a widespread popularity trend in China. As a result, the issue of sports related injuries is becoming increasingly prominent and urgently needs attention from all sectors of society. To effectively address this challenge, a systematic

epidemiological investigation and research on marathon sports in China should be conducted in the future to obtain scientific evidence. Based on this, efforts should be made to strengthen the prevention strategies and rehabilitation system construction of sports injuries, and to prioritize the protection and improvement of public health and well-being. At the same time, it is necessary to strengthen the promotion of health education and patriotic health campaigns, actively promote and facilitate the integration of evidence-based injury prevention functional exercise methods into daily life and sports practice. Looking ahead to the future, with the continuous expansion of marathon participants and the increasing demand for quality of life among the public, driven by the national fitness craze, the prevention and rehabilitation of sports injuries will become increasingly crucial.

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