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The causes of sports injuries of fencers and the coping strategies

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Abstract. Context Fencing is an ancient sport that originated in medieval European wars and gradually developed into a regulated competitive sport. It is a combination of elegant movements and flexible tactics, requiring athletes to be highly focused mentally and well-coordinated physically. Such high demands on movements and reactions reflect the excellent skills and agility of fencers. In order to achieve excellent competition results, many aspects are often involved in the training, including the comprehensive training of technical, physical, tactical and psychological quality. Such high-demand training and high-intensity competition make the probability of sports injury in the process of sports greatly increased. These injuries not only affect the athletes' immediate performance, but also may have a negative impact on their long-term career and shorten the athletes' sports life and may also bring huge psychological pressure and anxiety to the athletes. How to effectively avoid athletes' sports injury and improve the quality of training have become the key reasons for fencers to achieve good results. By understanding the causes and influencing factors of knee joint injury of fencers, it can provide theoretical basis for injury protection of fencers. At the same time, individual prevention or intervention strategies are adopted.

Keywords: Fencing, sports injury, rehabilitation

1. Introduction

Fencing is a very challenging sport and fencing is a typical asymmetrical sport, athletes must have extraordinary talent, strong explosive power and consistent perseverance. This is not only because the attack and defense changes in the game are extremely fast and frequent, but also because the players must make accurate and effective judgments and react quickly and flexibly according to the changes in the opponent's field in a very short time. In addition, the technical style of "fast, accurate, relentless and changeable" is the core of fencing. This style can effectively improve the players' ability to process, integrate and respond to various offensive and defensive information, overcome the nervous reaction, and make the technology play a normal role in the special situation of constant change. The lunge is one of the core movements in the attack of fencing. In fencing, the fencer must quickly thrust or cut the sword at the effective part of the opponent. This process requires the instantaneous explosive power of the hind legs to push the whole body out to complete the lunge sprint. At the same time, in the defensive phase, the fencer must retreat quickly or pull wide to avoid being hit by the opponent. Therefore, under the background of these rapid "forward" and "backward" attack and defense actions, fencers are affected by different degrees of impact during the game, resulting in acute soft tissue strains or even tears such

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as muscle ligaments of fencers. The epidemiological survey of high-level fencers in China shows that the prevalence rate of sports injuries is high, mainly in knee joint, lower waist and ankle joint, among which the prevalence rate of lumbar myofascitis, patellofemoral bone and cartilage injury, and end-tendon disease are high. For example, Olympic champion Sun Yiwen was injured in the semifinal of the women's epee team at the Tokyo Olympic Games and had to withdraw from the competition. Such sudden injuries, while rare, can have a significant impact on an athlete's career and mental state.

Current research shows that the coping strategies of fencers' sports injuries are rarely described in the previous literature. This paper summarizes the sports injuries that often occur in the process of sports for fencers and their causes and puts forward appropriate suggestions and coping strategies for the prevention of sports injuries, so as to reduce the probability of the occurrence of sports injuries for fencers and extend their sports life. Laying the foundation for the development of fencing [1].

2. The causes of fencing injuries

In today's sports competition, fencing is highly respected because of its unique skill and competition. However, the sport itself has the risk of injury, especially when the athletes in the pursuit of speed, strength and accuracy, the injury is naturally unavoidable, so the in-depth study of fencing injury and coping strategies appear to be particularly important, which plays a vital role in reducing the risk of injury and restoring the athletes' athletic ability. Through careful research and analysis, it was found that the average number of injuries per fencer is as high as 3.3 times per year, half of which (52.6%) are mild injuries. This statistic not only reveals the prevalence of injuries in fencing, but also highlights the potential risk of injury. Of greater concern is that lower limb injuries accounted for 47.2% of the most common injury sites, followed by upper limb injuries (26.4%), trunk injuries (21.4%) and head and neck injuries (5.0%). This distribution pattern reflects the high demands fencing places on athletes' lower limb strength and muscle endurance, as well as the intense antagonism and stress brought about by moving at high speed during competitions. And a closer look reveals significant differences in injury sites and severity between male and female fencers in different sword styles (foil, epee and sabre) [2-4].

In addition, the causes of injuries vary widely among fencers from country to country, which may be due to the different training environment, cultural background and training system of different countries, and there are also differences in competition rules and technical and tactical movements between different sword types, which are the reasons for the differences in the above-mentioned fencing injuries. To sum up, through the detailed division and in-depth study of fencing injuries, we can have a deeper understanding of the causes of injuries and formulate effective coping strategies accordingly. This can not only protect the health and safety of athletes, but also help them to play a better sports performance in competitions and give athletes, coaches and trainers the right rehabilitation strategy after athletes were injured.

2.1. Technical movement factors

High load effects of lunges, rapid direction changes and other movements on lower limbs and trunk. In fencing, technical movements are the building blocks that make up the unique charm and challenge of the sport, as well as a significant source of injury risk,especially lunge and quick change of direction, have become one of the main sources of sports injuries because of the high intensity load on the lower limbs and trunk of athletes. High load effects of lunges, rapid direction changes and other movements on lower limbs and trunk. As one of the most iconic steps in fencing, lunge requires athletes to burst out a powerful force at an instant and move the body's center of gravity forward in order to quickly approach the opponent or withdraw the defense. In this dynamic process, the knee joint and ankle joint of the hind leg bear great pressure [5]. Coupled with repeated execution, it is easy to lead to joint wear, muscle strain and even ligament damage. At the same time, in order to maintain the balance and posture of the body, the muscle groups of the torso also need to continue to be tight, over a long period of time, the waist and back muscles strain and pain problems will follow. Changing direction quickly is another skill that requires a lot of speed and flexibility. In the fierce transition between attack and defense, athletes need to adjust their body orientation in a very short time, which puts a severe test on the explosive power

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of the lower extremities, coordination and efficient work of the neuromuscular system. This series of movements not only put forward higher requirements for the stability of the knee and ankle joints, but also greatly increased the risk of muscle and ligament strain, especially in the insufficient warm-up or improper execution of technical movements, the probability of injury is significantly increased. In addition, the sudden stop and start movement in the rapid change of direction will also have an impact on the bone, which may cause serious consequences such as stress fractures in the long run [6].

Therefore, it requires athletes not only to pay attention to the standardization and accuracy of technical movements in daily training, but also to strengthen the strength training of lower limbs and core muscles to improve the overall stability and endurance of the body. At the same time, the training amount and intensity are reasonably arranged to ensure adequate recovery time, so as to effectively prevent sports injuries caused by technical movements, prolong sports career and maintain competitive status.

2.2. Training and competition environment

Improper arrangement of field conditions, quality of equipment, training volume and intensity. The training and competition environment of fencing is another important dimension that affects athletes' health and performance, covering many aspects such as site conditions, equipment quality and training arrangements. The site conditions directly affect the athletes' sports safety and technical performance. Slippery or uneven surfaces can cause athletes to lose their balance when moving or changing directions quickly, increasing the risk of falls and sprains. Poor lighting or visual distractions can affect an athlete's judgment of spatial distance and the movements of an opponent, increasing the likelihood of collisions and friendly injuries. Therefore, ensuring the professionalism and safety of competition and training venues, such as the use of professional shock-absorbing floors, maintaining appropriate lighting and ventilation, is the basis for preventing sports injuries. The quality of equipment cannot be ignored either. Ill-fitting or low-quality protective equipment such as fencing suits, masks and chest pads may not only break or shift in high-intensity confrontation, reducing the protective effect, but also may cause skin wear and lacerations due to friction and compression. The weight of the sword and the unreasonable design of the balance point will also increase the burden on the hand, and long-term use may lead to chronic damage to the wrist and elbow. The scientific arrangement of training amount and intensity is also the key to avoid sports injuries. Unreasonable training plans, such as overtraining and lack of recovery period, will lead to the accumulation of physical fatigue, muscle strength decline, slow reaction speed, not only affect the training effect, but also increase the risk of muscle strain, joint injury and so on. Especially during the preparation for the competition, although high-intensity concentrated training is helpful to improve skills, it is easy to cause overtraining syndrome if personalized adjustment and proper rest and recovery are ignored [7].

2.3. Individual differences

Susceptibility to injury by age, sex, physical fitness, skill level. In fencing, individual differences, including but not limited to age, sex, physical fitness and skill level, are one of the key factors that affect athletes' susceptibility to injury.

Age, as a reflection of the body clock, has a direct bearing on the athlete's ability to recover and the risk of injury [8]. Young athletes usually have good resilience, but are relatively inexperienced and immature, and may be injured due to improper execution of movements; Conversely, older athletes, while more experienced, are more prone to chronic injuries as they age and become less functional and less flexible in their joints. Gender differences should not be ignored. Physiological differences in strength, flexibility and endurance can affect the type and location of injuries. For example, female athletes may be at higher risk of injury during high-intensity confrontations due to their relatively weak muscle strength. Also,there is still debate that whether the participation of trans women in the female sporting categories is fair, specifically the retained male physiological advantage due to the increased testosterone compared to the cisgender females [9].

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The level of physical fitness directly affects the athletes' ability to resist injury. Good cardiorespiratory endurance, muscle strength, flexibility and coordination can not only improve athletic performance, but also cushion the impact of external forces to a certain extent and reduce the chance of injury. For example, strong core stability can help athletes maintain their balance during rapid swerve and lunges, reducing the risk of falls and sprains. Poor physical fitness, on the other hand, may make athletes more prone to fatigue in the face of intense training and competition, increasing the likelihood of injury. Skill level is another important factor. Highly skilled athletes tend to be able to judge their opponents' movements more accurately and effectively use techniques and tactics to avoid unnecessary physical contact and impact and reduce accidental injuries. Their movements are more economical and efficient, allowing them to maintain speed and power while minimizing wear and tear on their own bodies. On the other hand, unskilled athletes may be forced into a passive position due to stiff movements and slow reflexes, making them more vulnerable to injury from opponents or their own errors.

2.4. Psychological factors

The influence of competition pressure and mental fatigue on the reaction speed and judgment of athletes. Fencing is not only a physical competition, it is also a mental battle. In the highly tense competition environment, the competition pressure and psychological fatigue faced by athletes have a profound impact on their reaction speed, decision-making judgment and even the overall performance. As a dimension that cannot be ignored, psychological factors have a complex and far-reaching mechanism. Competition pressure, especially the pressure of major events, can significantly increase the psychological burden of athletes. This stress can come from the desire to win, the weight of external expectations, or the fear of failure. At high levels of stress, athletes' nervous systems are highly activated, which, if not managed effectively, can lead to distraction and extended reaction times. In a sport such as fencing, which requires split-second judgment and quick reaction times, even a small delay can lead to errors in the transition between attack and defense, increasing the risk of being scored by an opponent. In addition, excessive stress can cause muscle tension, affecting the flow and precision of technical movements and further reducing athletic performance. Mental fatigue, on the other hand, is the result of long-term accumulation, resulting from constant intense training, frequent competition schedules, and the constant need for mental adjustment. Mental fatigue not only impairs athletes' ability to regulate their emotions, making them more prone to depression and anxiety, but also directly affects cognitive functions, such as slower information processing and poorer decision-making quality. In fencing, a good mental state is a prerequisite for quick analysis of the opponent's tactics and flexible response. In the state of psychological fatigue, athletes may become conservative or impulsive in their strategic choices, miss the best time to attack, and even make mistakes in judgment at key moments.

2.5. Rules and techniques

Differentiated risk of damage due to the specific rules and technical requirements of different sword species. Fencing is divided into three types of sword: foil, epee and sabre. Each type of sword has its own unique rules and technical and tactical requirements, which also leads to different types of sword athletes in training and competition face different injury risks. The difference of rules and techniques and tactics directly or indirectly affects the athletes' action mode, confrontation intensity and competition strategy, thus shaping their own unique injury risk spectrum. Foil emphasizes skill and strategy, requiring players to score points through light and fast thrusts, and does not allow chopping. Therefore, foil athletes pay more attention to improving the speed and accuracy of the jab, which makes them in frequent fast sprint and emergency stop, lower limb muscles, knee, ankle and waist bear greater pressure, prone to muscle strain, joint sprain and chronic strain. At the same time, in order to quickly adjust the posture for defense or counterattack, the muscles and tendons of the upper limbs, especially the shoulder and elbow position, are also facing a high risk of overuse injury. Epee, on the other hand, uses the whole body as an effective scoring area, which encourages athletes to focus more on power and timing in the confrontation. Direct body contact is more frequent in epee competition, and athletes need

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to push each other with the sword to create a chance to attack, which not only increases the possibility of collision injury, such as shoulder impact injury, but also increases the demand for lower limb support strength, resulting in leg muscle and joint injury. In addition, in order to withstand the weight of the sword and react quickly, the wrists and elbows of epee athletes are often damaged by repetitive forces. Sabre, with its unique "priority" rule, requires athletes to react quickly and seize the opportunity, which not only tests the instant explosive power of athletes, but also puts forward extremely high requirements on their psychological quality and decision-making speed. Sabre game rhythm is very fast, athletes in the frequent change of attack and defense, easy to cause muscle strain or joint sprain due to excessive movement or overreaction, especially in the rapid change of direction and the execution of complex actions, lower limbs and spine bear uneven load may cause injury. The specific rules and technical and tactical requirements of different types of sabre not only shape their own unique sports aesthetics, but also bring differentiated sports injury risks. In view of these specific risks, athletes and coaching teams need to adopt special training strategies to strengthen the strength and flexibility of specific parts, and at the same time, through tactical simulation and psychological adjustment, improve the athletes' self-protection awareness and ability in high-intensity confrontation, so as to achieve the purpose of injury prevention and performance optimization.

3. Types and characteristics of fencing injuries

The types and characteristics of fencing injuries, as the core issue of athletes' health management, are not only related to the performance of the competition, but also the key to the continuation of athletes' career. These injuries can be roughly divided into two categories: acute injury and chronic injury, and each type of injury has its specific formation mechanism, manifestation and prevention strategy.

3.1. Acute injury

Acute injuries usually occur in the event of a sudden event in competition or training, this type of injury occurs suddenly and has obvious symptoms, including but not limited to muscle strains, ligament tears, and joint sprains. In fencing, the lower and upper limbs become a high incidence area for acute injuries due to their high intensity, instantaneous explosive force requirements and frequent body displacement. For example, lunges and rapid swerving movements can lead to leg muscle strains or knee and ankle sprains; The rotator cuff muscles and elbow ligaments in the upper extremities may be injured by hyperextension or twisting during rapid sword swings and blocks. Not only do these acute injuries immediately affect an athlete's competitive condition, improper management can also translate into chronic problems and prolong recovery time [10].

3.2. Chronic injuries

Chronic injury is the gradual accumulation of injuries caused by the repeated use of certain muscle groups or joints over a long period of time, which manifests as persistent pain and dysfunction. Among fencers, common chronic injuries include diseases of the end of the patellar tendon (jumper's knee), rotator cuff injuries, etc [11]. These injuries are mostly related to repetitive technical movements, excessive training or insufficient recovery. For example, continuous lunge exercise may increase the burden on the patellar tendon and lead to terminal patellar tendon disease; Frequent upper limb movements can lead to rotator cuff tendinitis or tendon tears. The accumulation mechanism of chronic injury emphasizes the scientific nature of training methods and the importance of rest and recovery. Prevention strategies need to focus on training variety and appropriate adjustment of intensity, as well as targeted muscle strength and flexibility training.

3.3. Analysis of special cases

The injury cases of famous athletes such as Sun Yiwen provide valuable practical teaching materials for the prevention and response of fencing injuries. Sun Yiwen suffered an unexpected injury in the women's team sabre semifinals at the Tokyo Olympics. She then underwent brief treatment and persisted in playing one game, but was unable to complete the entire game and was eventually substituted by her

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teammates. This incident highlights that even the top athletes cannot completely avoid the risk of sports injuries.These kinds of sudden injuries remind us that in addition to the usual precautions, athletes and teams need to have sound contingency plans in place, including knowledge of first aid on the spot, the ability to quickly assess injuries and quick access to emergency medical support. In addition, comprehensive physical training for athletes, enhancement of comprehensive physical quality, and cultivation of good mental toughness are also the key to prevent and effectively deal with sudden injuries. Through in-depth analysis of these special cases, prevention strategies can be further refined, the rehabilitation process after injury can be optimized, and more comprehensive protection and support can be provided to athletes.

4. Prevention strategies for fencers' sports injuries

A systematic and multi-dimensional approach is essential in the construction of the fencer injury prevention strategy, aiming to create a safer, more efficient and lasting training and competition environment for the athletes through comprehensive interventions [7].

4.1. Technical improvement and safety guidance

The accuracy and efficiency of technical movements are the key to reducing sports injuries. The coaching team should employ advanced biomechanical analysis tools to conduct a fine evaluation of the athlete's technical movements and identify and correct erroneous movements that may lead to excessive load or imbalance. Special attention should be paid to the details of high-risk techniques such as lunges and rapid change of direction, and through simulated confrontation and video feedback techniques, correct technique paths and force application should be reinforced to reduce unnecessary energy consumption and unnecessary body impact. At the same time, safety guidance should be used throughout training to educate athletes on how to maintain the quality of technical movements while taking protective movements to avoid damage in direct confrontations, such as reasonable use of distance control and fencing skills to mitigate the impact of the opponent's impact.

4.2. Physical training and body stability

The physical training program should be specific to the characteristics of fencing, focusing on the development of core strength, lower limb explosive power and endurance. Strengthening the core can improve the stability of the athlete's body, reduce unnecessary swings and twists during exercise, and indirectly protect the lower limbs and spine from injury. Explosive lower limb strength training should be combined with functional strength training, such as squats, jumps and one-leg balance exercises, to enhance knee and ankle joint stability, while improving reaction speed during exercise. Endurance training ensures that athletes maintain good physical condition during long competitions, reducing errors of judgment and deformation of movement caused by fatigue. In addition, flexibility training is added to improve joint range of motion and reduce the risk of muscle tension and strain.

4.3. Personalized training plan and monitoring

In view of individual differences, training programs should be tailored based on the athlete's physical fitness test results, technical characteristics, past injury history and other factors. Scientific training load monitoring systems, such as RPE (Subjective physical sensation rating) and HRV (heart rate variability) monitoring, should be adopted to adjust the intensity and amount of training in a timely manner to avoid overtraining syndrome and ensure that athletes train and compete in the best condition of recovery. Personalized training should also include the formulation of recovery strategies, such as hot and cold therapy, massage, nutritional supplements, etc., to speed up the recovery of the body and prevent the occurrence of chronic injuries.

4.4. Standardization of equipment and venues

Ensure that all training and competition equipment meets international safety standards and is regularly checked and updated, especially key protective equipment such as masks, chest pads, gloves, etc., to

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provide maximum protection. Venue selection and maintenance are equally important, requiring a flat, non-slip surface with good shock absorption and reduced risk of falls and slips. In addition, adequate lighting and no line of sight occlusion help athletes maintain the best visual perception and reduce accidental collisions caused by poor line of sight during competitions [11].

4.5. Psychological adjustment and stress management

Mental training is an integral part of the prevention of sports injuries. Through psychological counseling, mindfulness meditation, goal setting and mental toughness training, athletes can be helped to establish a positive mindset, effectively manage competition pressure, and improve the quality of decision making and reaction speed in high-pressure environments. Psychological intervention should also include psychological preparation for dealing with failures and injuries, ensuring that athletes can maintain emotional stability in the face of challenges, recover quickly from setbacks and maintain a long-term state of mental health.

5. Fencers' coping measures with sports injuries

It is inevitable that fencers suffer sports injuries in high-intensity training and fierce competitions, and scientific and reasonable coping measures are the key to ensure the safety of athletes, promote the rehabilitation process, shorten the recovery time and smoothly return to the competition.

5.1. Immediate treatment: popularization of on-site first aid knowledge and preliminary treatment

In fencing, once an acute injury occurs, such as a sprain, strain or collision injury, the first priority is to immediately take correct and effective on-site first aid measures. All coaches, team doctors and athletes themselves should be trained in first aid, the basic RICE principles (Rest, Ice, Compression, Elevation) and the initial treatment methods for different types of injuries. For example, in cases of suspected ligament tear or joint dislocation, avoid moving the injury and use a splint to prevent further injury. At the same time, the site should be equipped with first aid kits, including supplies such as ice packs, elastic bandages, and fixed splints, to ensure a quick response.

5.2. Rehabilitation plan: Customized and progressive rehabilitation strategies

It is essential to develop a personalized rehabilitation plan for acute injuries or chronic strain injuries. In the early stages of recovery, the focus is on controlling inflammation and reducing pain. Physical therapy such as ultrasound, electrical stimulation, and cold therapy can be effective in alleviating symptoms. This is followed by a gradual transition to functional training, which promotes blood circulation through low-intensity, low-impact activities, enhances blood supply to the damaged tissue, and speeds up the repair process. In the middle of rehabilitation, combine progressive resistance training with balance and coordination exercises to restore muscle strength and joint stability and avoid re-injury. In the later stage of rehabilitation, special technical training is gradually introduced to simulate actual competition scenarios to ensure that the athletes' technical movements will not regress due to injury before returning to training and competition.

5.3. Psychological support: comprehensive care and psychological intervention

Sports injuries not only affect the physical health of athletes, but also may cause a series of psychological problems, such as anxiety, depression, frustration and so on. Therefore, providing professional psychological support is an important part of the entire rehabilitation process. Psychological interventions include cognitive behavioral therapy, mental resilience training and emotional regulation techniques to help athletes face the injury, adjust their mindset and establish positive recovery beliefs. Teams should encourage open communication so that athletes can feel the emotional support from coaches, teammates and family members to enhance their sense of belonging and confidence. In addition, timely psychological counseling should be provided to guide athletes to properly deal with setbacks and challenges in the rehabilitation process, so as to lay a psychological foundation for a smooth return to competition.

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5.4. Re-entry strategy: Scientific evaluation and safe return

The progress of the athlete's rehabilitation needs to be comprehensively evaluated by the professional team, including physical fitness test, technical evaluation, psychological status inspection and medical examination by the doctor, so as to ensure the safe return on the basis of complete recovery. The evaluation should cover strength, endurance, flexibility, coordination and specialized skills to ensure that athletes are physically and mentally ready to return to high-intensity training and competition. Before the official return, some low-intensity competitions or simulated confrontations can be arranged as a "test water" to observe the athletes' adaptation in actual combat, adjust the training plan according to the feedback, and gradually increase the intensity and complexity of training until they are fully integrated into the team training and competition [12].

6. Conclusion

The prevention and coping of fencing injury is a systematic project, involving many dimensions such as technology, physical strength, equipment, psychology and individual differences. The key reasons lie in the improper execution of technical movements, the unsuitability of training and competition environment, the neglect of individual differences, the accumulation of psychological pressure and the challenge of specific rules and technical and tactical requirements. Effective coping strategies need to take into account immediate on-site first aid, customized rehabilitation plans, continuous psychological support and scientific return to competition strategies, to ensure that athletes can receive comprehensive and professional care after injury and return to competition safely and efficiently. The importance of individualized prevention and rehabilitation is self-evident. Every athlete has different physique, skill level, psychological state and injury experience. Therefore, the development of personalized training plans, rehabilitation programs and psychological intervention measures is the key to the success of prevention and recovery. This requires close collaboration between the coaching team, medical staff and scientific researchers, using advanced technologies such as biomechanical analysis, sports performance monitoring and mental health assessment tools to provide the most appropriate intervention plan for each athlete.

Future research directions should focus on long-term follow-up studies, focusing on injury occurrence patterns, rehabilitation effects and post-retirement health status of athletes throughout their careers, so as to provide empirical basis for formulating more scientific and sustainable prevention and rehabilitation strategies. At the same time, exploring the application of new technologies, such as the safety application of virtual reality technology in simulated actual combat training, the potential of wearable devices in monitoring athletes' physiological indicators and preventing overtraining, and the auxiliary role of artificial intelligence in the development of personalized training plans, are all worthy of further exploration. Through interdisciplinary cooperation, integrating the latest achievements of sports science, medicine, psychology and engineering technology, the aim is to provide fencers with a more refined and efficient injury prevention and recovery system, and promote the development of this ancient and elegant sport towards a safer and healthier future.

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