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Foot and ankle sports injury in cold areas

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Abstract

Exposure to cold environments significantly elevates the risk of sports-related foot and ankle injuries. Low temperatures induce stiffness in muscles, tendons, and ligaments, reduce tissue elasticity, and diminish overall joint flexibility. At the same time, frozen or hardened ground surfaces heighten impact forces while impairing the body's shock-absorption and adaptive response mechanisms. As a result, injuries such as ankle sprains (ligament tears), tendonitis, and stress fractures become more prevalent. Prevention is therefore essential and should focus on comprehensive warm-up routines, use of thermal and supportive equipment—including ankle braces—selection of footwear with adequate traction, and timely replacement of damp socks after exercise to maintain foot warmth and dryness.

Keywords

foot and ankle sports injury; treatment of foot and ankle sports injury; diagnosis of foot and ankle sports injury

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1 Introduction

Harbin welcomed the 2025 Asian winter games as a cold north wind swept through every corner of the city. The event has not only promoted the development of professional sports but also elevated the public enthusiasm for winter activities to new heights. As the number of ice and snow sports increases sharply[1], safety has become an issue that cannot be overlooked. Behind every graceful glide and jump lies a potential risk of injury[2]. The ankle, serving as a key structure for supporting the body and maintaining dynamic balance, is under unprecedented stress and vulnerability[3]. Muscle stiffness in low-temperature environments, unstable or complex terrain, and repeated impacts from high-intensity exercise collectively make foot and ankle injuries a critical concern in winter sports. The article will explore the mechanisms by which cold environment contribute to ankle injury in different sports, the common types of ankle injuries, and the subsequent management, treatment, and rehabilitation.

2 Injury to the ankle caused by cold-weather sports

In this paper, cold-weather sports are broadly classified into racing events and contact/antagonistic events. Racing events mainly include skiing, skating, and related speed- and skill-based sports. Antagonistic events primarily refer to ice hockey and similar high-impact sports. Although the types of ankle injuries vary across different sports, the overall injury rate remains higher[4].

2.1 Racing sports and related injuries

Racing sports, which integrate both speed and technical skill[5], impose high demands on ankle strength, stability, and coordination[6]. For recreational participants, insufficient professional training and inadequate physical preparation make them more vulnerable to ankle injuries while enjoying activities such as skiing or skating. Improper posture, sudden changes in terrain, or unstable ground conditions may readily result in injuries, such as sprains of the medial collateral ligament. Muscle stiffness in low-temperature environments further increases risk by reducing reaction speed and impairing neuromuscular coordination, thereby increasing the likelihood of falls and injure.

Professional athletes, despite having undergone strict training and benefitting from advanced equipment, still face significant challenges. High-intensity training and competition expose them to repetitive mechanical stress. High-speed turns, abrupt stops, and heavy landing impacts place substantial demands on ankle stability and load-bearing capacity. Long-term high-load exercise increases the likelihood of chronic injuries such as a stress fracture or chronic ligament strain[7], ultimately affecting the performance and athletic longevity.

2.2 Antagonistic sports and related injuries

Ice hockey, characterized by its high-intensity physical confrontations, poses considerable challenges to athletes' ankle. Frequent collision, high-speed skating maneuvers, and the risk of direct impact from sticks, pucks, or other players place the ankle at high risk of distortion, overstretching, or direct trauma. These injuries may include sprains, ligament tears, and even fractures, and acute injuries that are not managed properly can easily progress into chronic conditions[8]. Moreover, even withe professional protective equipment, the strength of impact in high-level ice hockey can exceed protective limits, highlighting the ankle as one of the most vulnerable structures in the sport[9].

3 Common types of ankle and foot injuries

3.1 Ankle Joint Injuries

In this study, ankle injuries are divided into two categories: ankle sprain and ankle fracture.

3.1.1 Ankle sprain

Acute ankle sprain is the most common lower-limb injury among athletes, accounting for 16% to 40% of all sports-related injuries[10]. Most sprains involve the lateral ligament complex, especially the anterior talofibular ligament. Because ankle sprains are often underestimated, many people resume walking or exercising within hours to days, predisposing them to chronic ankle instability. In a systematic review and meta-analysis, Wijnhoud *et al.* reported that up to one-third of patients with chronic ankle instability subsequently develop cartilage damage[11].

(1) Diagnosis of ankle sprain Magnetic resonance imaging (MRI) is the reference standard for evaluating ankle sprains, especially for evaluating soft-tissue injuries. MRI depicts the integrity of peri-ankle ligaments—distinguishing partial from complete tears—and demonstrates associated soft-tissue edema and hematoma.
(2) Treatment of ankle sprain Because ligament injury commonly accompanies an ankle sprain, timely protection and functional immobilization are essential. When a ligament is severely damaged, surgical repair or tightening may be required to restore stability and prevent chronic ankle instability and other late sequelae.

3.1.2 Ankle fracture

Ankle fractures are common, with an incidence of approximately 174 per 100,000 adults per year[12]. Patients typically present with pain, swelling, and ecchymosis; severe cases may show deformity and difficulty bearing weight. In cold-weather sports requiring rapid turns, jumps, and frequent falls, body weight and momentum generate horizontal shear forces at the ankle. These forces compress the medial and lateral structures, resulting in varus- or valgus-type fractures of the ankle joint[13].

(1) Ankle fracture diagnosis Diagnosis relies primarily on X-ray, computed tomography (CT), and, when helpful, 3D reconstruction. On radiographs, cortical disruption and visible fracture lines are characteristic, sometimes accompanied by joint incongruity or dislocation. When radiographs are insufficient—particularly for defining fragment number, size, displacement, or the detailed morphology of articular surfaces—CT is an excellent adjunct. CT clearly delineates fracture lines, comminution, step-offs, and associated syndesmotic or tibiofibular injuries, and can provide accurate three-dimensional detail to guide surgical planning.
(2) Ankle fracture treatment Management includes conservative and surgical options[14]. Conservative treatment is appropriate when displacement is minimal (≤ 2 mm), the articular surface is relatively congruent, or the patient's condition precludes surgery. Measures include limb elevation and local cryotherapy; for small (2–4 mm) displacements, closed reduction under anesthesia may restore alignment, followed by casting or a functional brace to limit joint motion and protect the ankle.
The principles of surgical treatment are to restore anatomic alignment, stability, and function, prevent complications, and enable rapid recovery. Indications include failure of closed reduction or conservative care, trimalleolar fractures, articular surface damage or displaced fragments, tibiofibular syndesmotic disruption, fractures with associated neurovascular injury, and open fractures requiring urgent debridement and stabilization.

3.2 Rupture of Achilles tendon

The Achilles tendon is the largest and strongest tendon in the body and one of the most frequently ruptured[15]. In winter, low temperatures increase muscles and tendon stiffness, and warm-up is often insufficient. A sudden, forceful contraction of the calf muscles can therefore generate high tensile loads on the tendon—especially in its relatively hypovascular midsubstance—predisposing it to rupture.

3.2.1 Diagnosis of Achilles tendon rupture

The Achilles tendon connects the calf musculature (primarily the triceps surae) to the calcaneus. When intact, squeezing the calf transmits force through the tendon to produce plantarflexion. A positive Thompson test—absence or reduction of plantarflexion with calf squeeze—is a key clinical sign of rupture[16]. This simple, rapid bedside test supports initial diagnosis and triage for imaging, such as ultrasound or MRI.

Imaging evaluation relies mainly on MRI and ultrasound. MRI provides detailed axial, sagittal, and coronal views to confirm rupture, localize the tear (proximal, midsubstance, or distal), and differentiate partial from complete disruption. It also depicts peritendinous edema, hemorrhage, and inflammatory changes, informing comprehensive assessment and treatment planning[17].

Ultrasound affords real-time dynamic visualization of the rupture site and tendon ends, is highly sensitive for diagnosis, and is noninvasive and cost-effective—making it well suited for rapid assessment and preoperative planning, particularly in emergency settings[18].

3.2.2 Treatment of Achilles tendon rupture

Treatment is commonly surgical, ranging from conventional open repair to minimally invasive techniques. The goal is to re-approximate tendon ends to restore continuity and function; in complex cases, augmentation with autograft, allograft, or synthetic materials may be considered. Postoperatively, immobilization (often about 6 weeks) is used, with careful wound care to prevent infection. After immobilization, a progressive rehabilitation program under professional guidance—focused on range-of-motion work, calf strengthening, proprioception, and balance—facilitates a graded return to activity.

3.3 Heel pain and plantar fasciitis

Calcaneal pain and plantar fasciitis have multiple potential causes, including heel spurs, osteoporosis, and heel fat pad syndrome (HFPS). In winter sports, inadequate insulation and repetitive impacts in cold environments often precipitate or exacerbate heel pain and plantar fasciitis[19].

Because etiologies vary, treatment is typically multimodal. Ruiz-Hernández *et al.*[20] compared botulinum toxin with platelet-rich plasma (PRP) injections and found both improved pain; botulinum toxin showed greater early (1-month) benefit, whereas PRP demonstrated superior long-term (1-year) outcomes. Sugino *et al.* compared low dose laser therapy with shock-wave therapy reporting functional improvement and pain relief with both, with low-dose laser showing a greater analgesic effect. Sugino and colleagues reported that structured stretching exercises significantly improve plantar fascia elasticity, underscoring the importance of stretching in management[21].

4 Summary

The causes, types, and severity of ankle injuries vary across different cold-weather sports. Under low-temperature conditions, muscle and joint flexibility decreases, ground hardness increases, movement techniques may be insufficient, and improper use of sports equipment can further compound injury risk. Together, these factors make the ankle joint particularly vulnerable during winter sports. Therefore, while enjoying the excitement and pleasure of ice and snow activities, it is essential to adopt effective preventive measures to protect the ankle from injury[22].

(1) Adequate warm-up: Before participating in any winter sport, a thorough full-body warm-up is crucial. Exercises that focus on strengthening the muscle groups around the ankle, such as ankle rotation, calf raises, lateral movement, can enhance flexibility, improve blood circulation, and reduce injury risk[23].
(2) Wear appropriate equipment: Choose well-fitting professional sports shoes or ski boots with adequate support to ensure stable ankle protection. Footwear should neither be too tight or too loose, so as to avoid impaired circulation or increased twisting risk. Consider wearing an ankle brace for additional stability and protection[24].
(3) Strengthen ankle stability: On non-training days, regular ankle-strengthening exercises—such as resistance training with elastic bands—can significantly enhance ankle stability and improve the ability to withstand external forces, thereby reducing the likelihood of sprain[25].
(4) Learn proper techniques: Both beginners and experienced participants should receive guidance from professionals to learn and maintain correct posture and movement skills. Proper sliding, turning, and stopping techniques not only improve performance but also play a vital role in preventing accidental injuries.
(5) Pay attention to environmental conditions: Before activity, inspect the sports field's safety and avoid icy, uneven, or overcrowded areas. In adverse weather, extra caution is needed, and activity intensity should be reduced—or stopped—if necessary.
(6) Ensure timely rest and recovery: After prolonged activity, allow sufficient rest and perform appropriate stretching and relaxation exercises. This supports muscle recovery and helps reduce injury risk associated with fatigue accumulation.

5 Conclusion

The flourishing development of winter sports depends on the enthusiasm and dedication of every participant. Ensuring safety—particularly reducing injuries to key structures such as the ankle joint—is essential to encouraging more people to engage in winter sports with confidence. Through in-depth analysis of injury patterns across various winter activities and the widespread dissemination of preventive knowledge, the incidence of injuries can be effectively reduced. At the same

time, such efforts enable more enthusiasts to enjoy ice and snow sports without fear of the cold environment.

When injuries do occur, timely and evidence-based treatment and rehabilitation are equally important to prevent secondary complications and facilitate a safe, efficient return to activity. At present, research on sports injury prevention at the population level remains insufficient. Future efforts should strengthen investment in this area, refine preventive strategies, and develop personalized protection plans. In doing so, science, technology, and educational resources can better safeguard the health and safety of every winter sports participant and collectively support the sustainable and vigorous development of winter sports in China.

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Research ethics

Not applicable.

Informed consent

Not applicable.

Author contributions

Wang H and Zhu Z were responsible for research design and manuscript writing, Zhang H Y and He H were responsible for literature review and manuscript submission.

Use of large language models, AI and machine learning tools

No large language models, AI or machine learning tool was used for any part of the present study.

Conflict of interest

The authors declare no competing financial interest.

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Data availability

All relevant data are within the manuscript.

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