Lower Extremity Injuries in Snowboarders

Bilal Mahmood, BA, and Naven Duggal, MD

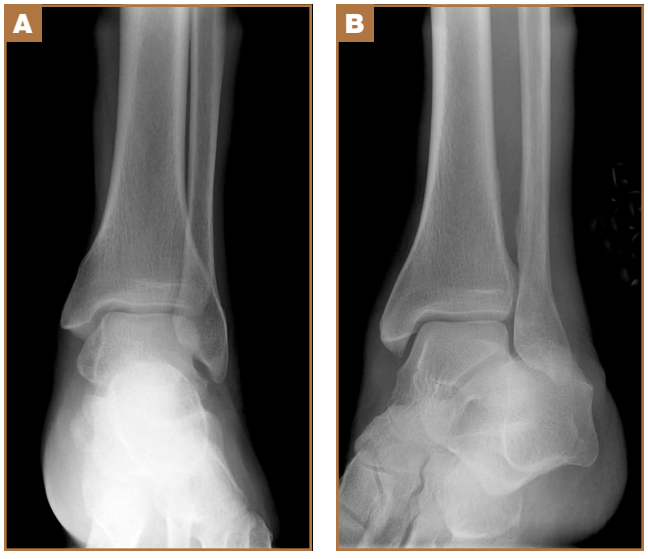
Abstract

The popularity of skiing and snowboarding has increased tremendously over the past few decades. Whereas skiing has been an established winter sport for some time, snowboarding was created only in the 1960s. The great surge in popularity of snowboarding was sparked by its inclusion in the 1998 Winter Olympics. With increased participation in these winter activities has come a tremendous rise in injuries, despite equipment changes and promotion of safety behavior. Although participants in these sports share many common lower extremity injuries, the unique characteristics of skiing and snowboarding lead to marked differences in injury rates and mechanisms of many specific injuries of knee, foot, and ankle. In this article, we review the literature on the epidemiology of lower extremity injuries associated with snowboarding and the associated mechanisms of injury.

Epidemiology

The several studies of lower extremity injuries sustained while skiing and snowboarding have differed markedly with respect to patient demographics. Kim and colleagues[1] compared snowboarding and skiing injuries over 18 seasons at a Vermont ski resort and found that the injury rate, assessed as mean number of days between injuries, was 400 for snowboarders and 345 for skiers. However, most snowboarding injuries were wrist injuries and generally of the upper extremity, whereas skiing injuries were mainly lower extremity injuries. Overall, young and inexperienced snowboarders had the highest injury rate. In a study on skiing and snowboarding injuries through 4 Utah seasons, Wasden and colleagues[2] found that mean age at injury was 41 years for skiers and 23 years for snowboarders. This corroborates the finding from several studies[1-3] that snowboarders tend to be younger. Snowboarding is a newer sport with many beginners. However, Ishimaru and colleagues[4] found that lower extremity injuries may be associated with experienced snowboarders, who may be prone to take more risks and tackle more challenging slopes. Experienced snowboarders are also likely to sustain lower extremity injuries from falling, because of their risk-taking behavior.[5]

Figure 1. Ankle radiographs. (A) Anteroposterior view of ankle; (B) mortise view of ankle.



Although upper extremity injuries account for most snowboarding injuries, lower extremity injuries are a significant issue.[6] Modern equipment and more challenging slopes have allowed snowboarders to attain great speeds going down slopes—leading to a surge in lower extremity injuries.[7] Lower extremity injuries sustained during snowboarding are more likely to be on the leading side[4]; the ankle is the most frequent fracture site. Unlike snowboard equipment, modern ski equipment, including new boots and binding systems, is designed to reduce ankle injuries and lower leg fractures.[6] The decline in foot, ankle, and tibia fractures can be attributed to taller and stiffer boots, which offer the lower extremities more protection.[8]

Figure 2. Coronal computed tomography of lateral process talus fracture.

Authors' Disclosure Statement: The authors report no actual or potential conflict of interest in relation to this article.

Figure 3. Sagittal computed tomography of lateral process talus fracture.

Figure 4. Sagittal magnetic resonance imaging of anterior cruciate ligament rupture.

Figure 5. Sagittal magnetic resonance imaging of bone bruising in femur and tibia associated with anterior cruciate ligament rupture.

Mechanism of Injury

Talus Fractures

An increasingly common injury among snowboarders is a fracture of the lateral process of the talus; this injury accounts for 32% of snowboarders' ankle fractures.[6] The lateral process of the talus—wedge-shaped and covered in articular cartilage—is involved in the subtalar and ankle joints.[9] A fracture here is often misdiagnosed as an ankle sprain (**Figures 1–3**).[6,9,10] The exact mechanism of injury remains controversial, and several biomechanical factors seem to be involved. Funk and colleagues[11] conducted a cadaveric study and concluded that eversion of an axially loaded, dorsiflexed ankle may be the primary injury mechanism for fracture. Furthermore, snowboarders have their feet in a position perpendicular to the board, and a fall parallel to the board could increase the eversion force on the ankle of the leading leg. Valderrabano and colleagues[9] conducted a clinical study of 26 patients who sustained this injury from snowboarding. All the patients reported they had felt an axial impact from falling, jumping, or unexpectedly hitting a ground object, and 80% reported a rotational movement in the lower leg during the impact. The authors concluded that axial loading and dorsiflexion were not the only factors involved in lateral process talus fractures, and an external moment is necessary to cause this injury from a forward fall.[9]

Anterior Cruciate Ligament Injuries

Although snowboarders' lower extremity injuries are primarily ankle injuries, snowboarders are also at risk for serious knee issues when landing from jumps. In skiers, anterior cruciate ligament (ACL) injuries have 5 well-established mechanisms, all involving separation of the feet and a twisting force in the knee (**Figures 4, 5**): boot-induced anterior drawer mechanism, phantom-foot mechanism, valgus-external rotation, forceful quadriceps muscle contraction, and a combination of internal rotation and extension.[8,12] A valgus–external rotation mechanism of knee injury occurs when external rotation of the tibia results from the skier catching the inside edge of the front of the ski. A valgus force acts on the knee as the lower leg is abducted during forward momentum. The torque created on the knee joint is amplified by the length of the knee and commonly results in an ACL injury or medial collateral ligament injury.[6] Reports indicate that the phantom-foot mechanism is the most common mechanism of ACL injury among skiers.[6,13,14] In this situation, internal rotation of the knee results when an off-balance skier falls backward, which causes the knee to hyperflex. The skier catches an inside edge on the snow, which creates a torque that rotates the tibia relative to the femur and results in injury to the ACL.[6,14] A boot-induced anterior drawer mechanism occurs during a landing, when the tail of the ski lands first and in an off-balance position, resulting in a load transmitted through the skis to the skier; this load causes an anterior drawer of the ski boot and tibia relative to the femur, straining the ACL and causing ACL rupture.[6,13,14] In the forceful quadriceps muscle contraction mechanism of ACL injury, a forceful quadriceps contraction occurs after a jump to prevent a backward fall. With the knee in flexion, this quadriceps contraction causes an anterior translation of the tibia, resulting in ACL rupture.[13,14]

The mechanism of injury differs in snowboarding, in which both feet remain attached to the board. Davies and colleagues[15] examined 35 snowboarders who sustained ACL injuries after a flat landing from a jump and concluded that snowboarders preparing for a landing exhibit more quadriceps contraction, which increases the loading force on the ACL during landing. Furthermore, the snowboarder's stance on the board, with the front foot slightly rotated relative to the board, results in a slight internal tibial rotation of the knee and establishes a posture that makes the snowboarder susceptible to injury. However, the lower incidence of knee injuries among snowboarders compared with skiers may be attributable to the fact that there is a limited amount of torque that can be generated on either knee as both feet are fixed to the board.[16]

The increased quadriceps force in anticipation of a landing, combined with the internal tibial rotation of the knee caused

by the snowboarder's stance, may be the primary mechanism of ACL rupture in snowboarders.[15]

Injury Prevention Strategies

Prevention strategies require an identification of injury risk factors for snowboarders. Hasler and colleagues[7] conducted a study with 306 patients to identify variables that presented a risk for snowboarders. Low readiness for speed, bad weather, and bad visibility, as well as snow conditions, were found to be significant risk factors.

Skiers' overall injury rate has decreased over the past 60 years, and this decrease has been attributed in part to improved ski technique and instruction.[17,18] Improperly adjusted ski bindings are the culprit in many equipment-related lower extremity injuries, and beginners are at much higher risk for such injuries. Lessons and comprehensive safety training could reduce this injury rate.[17,19] Several awareness video and training programs focusing on injury prevention have reduced knee sprains in ski patrollers compared with controls by 62% in 1 study; a similar program reduced injury by 30% in nonprofessional skiers.[17] A study of injured snowboarders during a winter in Scotland found that 37% of the patients had no formal instruction or training in correct snowboarding and falling technique.[20] Training programs for snowboarders could yield meaningful results in injury prevention and avoidance of risk-taking behavior among snowboarders.

Soft-shelled boots may also increase injury risk for snowboarders. Such boots allow for a wider range of ankle motion and offer little protection from extreme joint movements.

Advances in equipment have also had an impact on the incidence of skiing injuries. Ski bindings protect skiers in 2 ways. First, the binding keeps the boot attached to the ski and prevents unintended release on difficult terrain. Second, the binding releases the boot from the ski during extreme conditions to prevent the skier from experiencing extreme forces or moments that could result in injury. Functional failure in ski bindings has been implicated in increased incidence of knee injuries and ligament rupture. In a study of injuries sustained by recreational alpine skiers in Japan, Urabe and colleagues[21] found that 96% of those injured stated that the ski bindings had not released at time of incident. The effects of binding adjustment and maintenance among snowboarders have not been fully investigated, and there are no set guidelines for individual snowboarders on appropriate binding level. However, as there is a range of binding adjustment options available, snowboarders may have an optimum level that maximizes both mobility and protection from injury.[22]

Soft-shelled boots may also increase injury risk for snowboarders. Such boots allow for a wider range of ankle motion and offer little protection from extreme joint movements. Soft boots are generally preferred among snowboarders because they allow for increased mobility for sharp turns and maneuvers. However, modification of the stiffness of boots that limit ankle and foot joint mobility could reduce the incidence of ankle fractures and sprains among snowboarders.[22]

Summary

Snowboarding has become increasingly popular worldwide. It attracts a loyal group of amateur athletes and has developed into a billion-dollar industry with a growing rank of professionals. Although most snowboarding injuries are upper extremity injuries, the foot, ankle, and knee represent commonly injured areas among recreational and experienced snowboarders. Advances in ski equipment have significantly reduced the incidence of ankle injuries, but rising knee ligament injuries continue to pose a challenge. Foot and ankle injuries remain an issue in snowboarders despite advances in equipment and safety. New snowboard designs and boot and binding modifications may hold promise in decreasing the risk for injury in these athletes.

Mr. Mahmood is Research Student, Department of Orthopaedic Surgery, Beth Israel Deaconess Medical Center, Boston, Massachusetts. Dr. Duggal is Attending Orthopaedic Surgeon, Syracuse Orthopedic Specialists, Syracuse, New York.

Address correspondence to: Naven Duggal, MD, Syracuse Orthopedic Specialists, 5824 Widewaters Parkway, Syracuse, NY 13057 (tel, 315-251-3100; fax, 315-449-9923; e-mail, naven.duggalmd@sosbones.com).

Am J Orthop. 2014;43(11):502-505.

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