

# Snow skiing injuries

**BACKGROUND** Skiing is a sport that has exploded in popularity over the past 20 years. There are estimated to be 200 million skiers worldwide.

**OBJECTIVE** This article outlines the type and prevalence of ski injuries, and measures that have been made to reduce the incidence of injuries to skiers.

**DISCUSSION** The incidence of injury has decreased with the development of improved equipment, resort management and skier preparation. This decrease has been reflected in a lower rate of foot, ankle and tibial injuries. The overall incidence of knee injuries has increased and in particular an increase in more serious knee injuries. Snowboard injuries now account for approximately half the presentations to ski resort medical centres.

Snow skiing may date back to 3000 BC when the tusks of animals were said to be used by hunters as a method of crossing the snow.<sup>1</sup> Recreational skiing as we know it today originated in Scandinavia about 200 years ago.<sup>1</sup> Since that time it has grown into a global recreation with estimates of over 200 million skiers worldwide.<sup>2</sup>

Estimates from the United States in the 1950s put the incidence of injuries at approximately 7–10 injuries per 1000 skier days.<sup>3</sup> Since then, the incidence of injury has been observed to have fallen to around 3–4 injuries per 1000 skier days.<sup>4</sup>

More recently, with the increasing popularity of snowboarding, the number of injuries has begun to increase again as the number of individuals on the snow increases. Snowboarders now account for approximately half of all ski resort injuries. They tend to present with more upper limb injuries while traditional alpine skiing has a greater tendency toward lower limb injuries. The largest single group among these are injuries to the knee with medial collateral ligament injuries being the most common.<sup>5</sup>

Statistics collected from one Australian ski resort generally reflect a similar profile to that seen in the USA and Europe.<sup>6</sup> Over the past 10 years there has been a steady increase in the number of injuries seen, reflecting the increased resort traffic. Approximately 60% of patients at mountain medical centres will be brought in by the ski patrol while the remainder will walk in by themselves. On a busy day at one resort with about 8000 people on the snow, the medical centre will treat approxi-

mately 30–40 injuries. A certain number will take themselves off the mountain and avoid any statistical analysis, however, the incidence and breakdown resembles experience overseas.

Ski injury epidemiology over the past 40 years has been driven by a number of factors. Physicians' ability to accurately complete a diagnosis has improved. Better general clinical understanding of injury principles and better imaging methods mean that nonspecific diagnoses such as 'internal derangement of the knee' have decreased while more specific diagnosis such as a graded medial collateral ligament (MCL) or anterior cruciate ligament (ACL) injury have increased.<sup>2</sup> Johnson et al provided information about the injury trends in Vermont between 1972 and 1994.<sup>7</sup> There was a large decrease in the incidence in the first half of that period and the incidence has plateaued since then. Much of the improvement during this period is probably attributable to:

- improved ski equipment
- improved slope grooming and management
- improved management of rental equipment through centres which must now adhere to uniform standards to minimise risks
- improved preparation and tuition of individuals, and
- more comprehensive management of ski areas including traffic control and ski lift management.

## Lower limb injuries

Lower limb injuries account for the greater pro-

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**Figure 1.** ACL injury

portion of alpine ski injuries. The incidence has declined dramatically since the early 1970s because of improved boot and binding technology combined with more careful binding adjustment. During this time, upper body injuries have remained essentially constant.

One study by Hauser demonstrated that a large number of bindings were set at least 20% above recommended release levels.<sup>8</sup> When compared to a controlled group of skiers in whom bindings had been properly set, the nonadjusted group had four times the incidence of binding related injuries. Ekeland<sup>9</sup> found that the factors most effective in reducing equipment related injuries included correct adjustment and regular self testing by the skier to demonstrate that he can release both the toe piece and the heel piece by simply twisting or stepping out of them. These measures have seen the incidence of ankle sprains and tibial fractures decrease dramatically since the early 1970s.

### Knee

Knee injuries are the most frequent presentation in downhill skiing. They account for approximately 35% of all injuries.<sup>5,7</sup> Grade 1 and Grade 2 MCL injuries account for the largest number of presentations. The difficulty with this group is that they will often not present for treatment on the moun-

tain and, as such, their incidence is probably underestimated.<sup>5</sup>

Meniscal injuries also account for a significant proportion of knee presentations, although they are reported less frequently by skiers than other sports. Combined ACL and MCL injuries or the triad of ACL, MCL and meniscal injuries occur quite frequently.<sup>1</sup> The frequency of severe knee injuries has increased over the past 10–15 years.<sup>1</sup> They generally involve disruption of the ACL (Figure 1). This increased incidence may be the result of improved diagnosis with a better general clinical understanding of the nature of knee injuries as well as the use of magnetic resonance imaging (MRI). It also appears that while modern boots and bindings protect the ankle and tibia, they do transmit some of this force up to the knee. Binding adjustments are set to prevent fracture of the tibia, and it may be that binding release speeds are too slow to protect the knee, even when correctly set.<sup>10</sup>

Ettlinger et al<sup>11</sup> prospectively followed the rates of knee injuries in a single ski field over 12 years. They found that while most lower limb injuries had decreased, there was a large increase in severe knee sprains involving the ACL. They identified two common mechanisms. The first is the ‘phantom foot’ ACL injury, which is sustained while falling backwards and twisting on the downhill leg. The second is the ‘boot induced’ ACL injury, which occurs during hard landings while off balance. The knee is fully extended and the back of the boot drives the tibia forward in relation to the knee (Figure 2).

A group of ski resort employees were taught to avoid these mechanisms and they significantly reduced their incidence of severe knee injury. However, when the same training was applied to a nonexpert group of skiers they were not able to reduce their incidence of severe knee injury. The application of this training protocol is therefore still unproven.

Tibial plateau fractures are associated with high energy mechanisms (Figure 3). They almost always involve the lateral plateau and their incidence is said to have increased over the past 10 years; this is probably related to stiffer boots. The force involved is generally a valgus load, which compresses the lateral compartment.<sup>2</sup>

Modern ski equipment has reduced the incidence of foot, ankle and lower tibial injuries while

doing very little to protect the knee. The protection of these more distal structures may be to the knees detriment. A breakthrough that will reduce the incidence of knee injuries is still to come.

### Tibial and ankle injuries

There has been a dramatic decrease in the incidence of tibial and ankle injuries among adult skiers since the 1970s, however, they are still seen regularly in a busy ski resort. Interestingly the incidence of tibial fractures among children has essentially remained unchanged throughout this time.<sup>7</sup>

Common presentations of tibial injuries include spiral fractures of the middle and lower thirds. This may be associated with an intact fibula. It is not unheard of for children to present with isolated spiral tibial fractures, on which they are still able to walk. Boot top injuries (including fractures) that can present as a result of impingement on the front of the boot are still seen although their frequency has decreased.

Ankle fractures result from a rotary force of the ski that is transmitted to the ankle. These are generally associated with a combination of low boots and failure of bindings to release.

High speed comminuted injuries are similar to those seen with almost any form of multitrauma. They can be open or closed and are commonly associated with other injuries. Their severity is usually related to the speed of the fall, and they are usually seen in more advanced skiers, who tend to go faster (Figure 4).

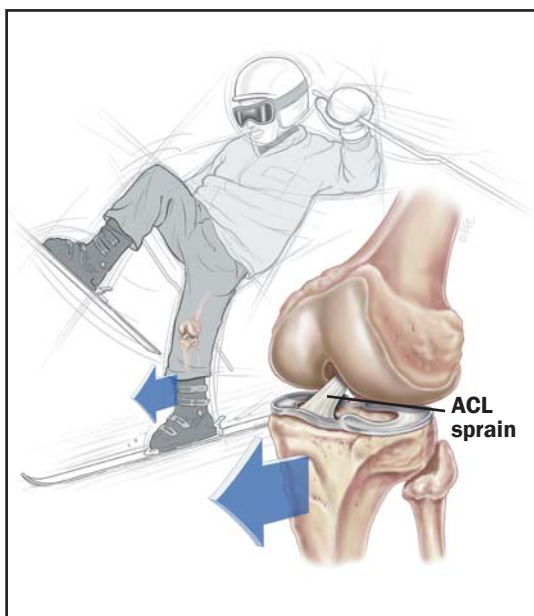


Figure 2. Boot induced ACL injury

### Hip injuries

Hip injuries are relatively uncommon, however, posterior dislocations relating to high speed impacts with a flexed hip can occur.

### Upper limb injuries

The most common upper limb injury in alpine skiers is the 'skiers thumb' from a fall with a ski pole in the hand resulting in injury to the ulnar collateral ligament of the thumb. These account for approximately 10% of all alpine ski injuries.<sup>5</sup>

Shoulder trauma accounts for another 5-10% of all alpine ski injuries.<sup>12,13</sup> These include anterior shoulder dislocations, rotator cuff tears and acromioclavicular (AC) joint injuries. Anterior dislocation is the largest subgroup of the shoulder injuries and it results from a fall onto an outstretched hand or an abduction external rotation force as the skier moves past a strongly planted pole. There is also a high incidence of associated rotator cuff injuries.<sup>12</sup>

Management of these shoulder injuries is essentially the same as in the nonskiing population. Older patients have a lower incidence of recurrent dislocation, however, they have a higher incidence of associated rotator cuff pathology. Snowboarders have a much higher incidence of upper limb injuries than skiers with wrist fractures, shoulder injuries and a variety of hand and thumb injuries.

### Head and spine injuries

Head and spine injuries account for approximately 7% of snowfield trauma and generally the incidence



Figure 3. Tibial plateau fracture



Figure 4. High speed injury

has remained unchanged.<sup>7</sup> Mechanisms vary from simple falls to high speed collisions with immovable objects, which generally carry more severe or fatal consequences. Typically these injuries are sustained by men in their 20s to 30s who are reasonably proficient skiers. This probably reflects risk taking behaviour increasing with their confidence, while speed is a significant component.

Skiing related deaths are generally associated with head or neck injuries. Fortunately, these are relatively infrequent. An estimate of approximately one death per one million skier days compares well with a number of other sports such as ski touring, hiking, rock climbing and a number of water sports.<sup>2</sup>

Efforts to reduce the incidence of these injuries will probably centre around resort management issues including reducing the merging of high speed and low speed trails, better marking of obstacles, and grooming to avoid high speed cruising.

### Conclusion

There is no doubt that alpine skiing remains one of the riskiest sports regularly undertaken by a large and diverse adult population. There are however, several strategies that seem to effectively reduce the incidence of injuries. These include:

- early tuition to get through the novice stage of skiing as quickly as possible
- effective preconditioning to improve strength, endurance, and reaction times
- the use of professionally adjusted, modern equipment which is tested each day before skiing
- skiing at speeds and in conditions which are consistent with ability, and
- as a large number of ski injuries occur toward the end of the day, stopping skiing each day before fatigue impairs the ability to correctly assess conditions.

Feagin et al<sup>10</sup> noted several risk factors for injury including a lack of condition. They point out that most recreational skiers are often under prepared so that by day three of a ski holiday the quadriceps have little strength or protective reaction. They suggest the rule of three:

1. Quit skiing before 3 pm
2. Beware of skiing at over 3000 m
3. Go shopping on day three.

Conflict of interest: none declared.

### SUMMARY OF IMPORTANT POINTS

- Many injuries result from poorly adjusted bindings.
- Improved boot technology is tending to protect the ankle and tibia at the expense of the knee.
- The fibula may be intact despite a spiral fracture of the tibia.
- Prevention of injury depends on adequate preparation of the skier, the equipment and the ski field.

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