

Reducing the risks for traumatic and overuse injury among competitive alpine skiers

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To achieve success, skiers attempt to optimise various biomechanical parameters (eg, trajectory, velocity, interaction between the skis and snow, energy) that influence performance,¹ but this increases risk of injury.² It is therefore not surprising that injuries are common among alpine skiers.³

To reduce the injury rate, the International Ski Federation (FIS) regulates ski length and width, sidecut radius, and the distance between the foot and ground. In the case of slalom skis, only the minimal waist width is regulated (≥ 63 mm), while in other disciplines the maximal waist width is regulated by FIS (typically ≤ 65 mm). On hard snow, wider skis are associated with an elevated risk for injury,⁴ so we suggest that it may be wise to revise this FIS regulation.

Measures concerning the geometry of skis implemented recently have contributed significantly to the 26% reduction in absolute injury rate (injuries/100 athletes/season) (risk ratio 0.74, 95% CI 0.63 to 0.87).³ We acknowledge that new regulations concerning helmets, the development of wearable airbags, and an enhanced awareness of the influence of external conditions most likely have contributed as well. At the same time, additional approaches designed to elucidate the multifactorial causes of injury are warranted. Since it appears impractical to regulate other properties of the skis (eg, bending/torsional stiffness, edges and running base) during official competitions, we propose that the following measures might improve safety in connection with competitive alpine skiing.

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IMPROVE THE SAFETY-RELEASE IN SKI BINDINGS

At present, the largest proportion of World Cup injuries involves the knee.³ To avoid inadvertent release, the safety-release in bindings is set considerably higher than the International Organization for Standardization (ISO) standard. If the torque and/or force required to open the ski binding when needed (eg, when an accident occurs) is too high, extensive torque is transferred to the knee joint. The mechatronic safety-release designs, that is, designs synergistically integrating mechanics, electronics and control theory to implement the knee biomechanically safe loading envelope, proposed for recreational skiing⁵ or even an emergency release that can be triggered manually⁶ might also be suitable for competitive skiers. A mechatronic design could include parameters such as knee angle and/or muscle activation into the algorithm that governs release. For example, this approach could be used to address injuries to the ACL caused by the 'dynamic snowplough' or 'landing back-weighted' mechanisms.⁷

DETERMINE WHY THE RATE OF INJURY AMONG SKIERS IS HIGHER DURING COMPETITIONS THAN TRAINING

Although the number of days and, in particular, runs involved in competitions and official training are lower than for other types of training, 71% of the injuries to World Cup skiers during the past decade have occurred during the former,³ despite the fact that the measures taken to ensure safety are presumably greater during competitions. One possible explanation is that skiers choose a more aggressive line and higher speeds during competitions, another being the more demanding slopes and courses during competitions, especially in connection with speed disciplines. It would probably be highly beneficial to plan and regulate the terrains and courses used in competitions more carefully.

EVALUATE THE POTENTIAL CAUSES OF OVERUSE INJURIES

Most research in this area has focused on acute injuries related to skiing, whereas

overuse injuries (on-and-off snow) have received little attention. To reduce such injuries to the lower back, Spörri *et al*^{8,9} proposed controlling and/or reducing the frontal and lateral bending, as well as torsion of the trunk and peak loads while skiing. Moreover, these investigators suggest that 'superior core stability and lumbar corsets' might effectively control spinal movement and avoid unwanted amplitudes and that minimal offset of slalom gates should be avoided. Other than these studies, little is known about the nature and frequency of overuse injuries, including when and why they occur during training and competition by alpine skiers both on-and-off snow. Future studies should explore the causes of overuse injuries to provide evidence-based recommendations of relevance to young and senior alpine ski racers.

CONCLUDING WORDS

Changes to skiing equipment, particularly the ski-plate-binding-boot unit, should be assessed thoroughly for the risk of both trauma and overuse injury prior to implementing any such change. It is important that research groups focusing on skiing safety and performance strive for consensus, especially since experiments on alpine skiing are complex, involving a variety of slopes, snow/weather conditions and course set-ups. In the future, musculoskeletal modelling, computer simulations and simulated skiing in the laboratory could play a greater role in research designed to provide a basis for effective preventive measures.

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