Equipment designed to reduce risk of severe traumatic injuries in alpine ski racing: constructive collaboration between the International Ski Federation, industry and science

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Developing and implementing effective prevention measures is vital to protect the health of athletes. In 2006, the International Ski Federation (FIS) established the FIS Injury Surveillance System. Following the sequence of injury prevention research suggested by van Mechelen *et al*,¹ various studies characterised the epidemiology, risk factors and mechanisms of injuries in alpine ski racing.^{2–5} From 2006 to 2012, the absolute rate that World Cup athletes sustained injuries was 36.2 injuries/100 athletes/season.² Across all competition disciplines, most injuries are known to occur while turning, either resulting from specific mechanisms while the skier is still skiing or during crashes.³ According to the perception of 61 expert stakeholders of the World Cup ski racing community, one key injury risk factor is the 'system ski, binding, plate and boot'.⁴ Experts stated that the ski equipment used at this time was 'too aggressive at the ski-snow-interaction', 'too direct in force transmission' and 'hard to get off the edge once the ski is carving'.⁴ Moreover, 'speed in general' was another major risk factor.⁴ In fall or crash situations, the magnitude of speed and, therefore, of kinetic energy, is particularly important, since during the impact, kinetic energy is dissipated over a short distance, which places high forces on the body.

TURNING RESEARCH INTO ACTION—CRITICAL PARTNERSHIPS

To address these concerns, an expert group consisting of researchers, FIS Race Directors and technicians of four ski manufacturers named by the Ski Racing

Suppliers Association (ie, Atomic, Fischer, Head, Rossignol) defined new giant slalom and downhill skis with the aim of reducing the risk of injuries. Owing to the constructive and commercial considerations of the ski manufacturers, as well as the restrictions with respect to an appropriate execution of the rules by FIS, not every technical solution was viable.

This Injury Prevention and Health Protection (IPHP) themed issue of *BJSM* includes four independent experimental studies that document the in-field evaluation process of the aforementioned giant slalom and downhill ski prototypes.^{6–9} Kröll *et al*⁶ discovered that giant slalom skis with greater sidecut radius can reduce the kinetic variables related to, as well as the athletes' perception of, aggressive ski behaviour, which has been suggested to be one key risk factor for knee injuries. While this preventative gain increased as sidecut radius increased, there was a significant loss in visual aesthetics for the skis with the greatest tested sidecut radius (ie, 40 m). Spörri *et al*⁷ experimentally demonstrated that the observed sidecut-induced (not skier action-induced) increase in ski turn radius provides indirect evidence of less self-steering of the skis with greater sidecut radius. Self-steering is known to play a central role in the mechanisms of anterior cruciate ligament rupture in alpine ski racing. Another study by Kröll *et al*⁸ focused on the effect of sidecut radius on kinetic energy in giant slalom and found a reduction in average kinetic energy of up to 5.6% when skiing on skis with greater sidecut radius; this knowledge may provide additional preventative gain with respect to knee and impact injuries. Linking the findings of these three ski prototype studies in Giant Slalom, we conclude that altered ski geometry, and, in particular, reducing sidecut radius, may increase athlete safety. However, skis with a radically greater sidecut radius (ie, 40 m) might lead to a significant loss in the attractiveness of the sport. Thus, from an implementation

point-of-view, potential benefits and costs must be weighed against each other. The study by Gilgien *et al*,⁹ in this IPHP issue, is the first to generate equipment-related knowledge in Downhill skiing. For steep terrain, kinetic energy was reduced by 3.1% on average for longer skis with reduced width and standing height—a reduction that is considered clinically relevant in view of the high speed/kinetic energy present in Downhill skiing/crashes. Nevertheless, these equipment-related reductions in kinetic energy are smaller than those that can be achieved by altering ski courses.

REGULATION—ANOTHER DIMENSION OF INJURY PREVENTION

On the basis of the aforementioned project process, FIS introduced new equipment rules for season 2012/2013. To complete the sequence of injury prevention research by van Mechelen *et al*,¹ the effectiveness of the new equipment rules needed to be tested. Because injury prevention is an ongoing process with different simultaneously applied prevention strategies, and because we have limited statistical power when dealing with a statistically 'small' cohort (ie, injured World Cup ski racers), this was challenging. Therefore, it is remarkable that Haaland *et al*¹⁰ report a lower overall injury rate in the three seasons that followed the new ski regulations compared to the preceding six seasons with previous rules. Our ongoing injury surveillance should provide more data that will result in greater knowledge of the effect of these and other prevention efforts by FIS on specific injury rates such as those for knee injuries, ACL ruptures and male and female subgroups, as well as competition disciplines.

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