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EDITORIAL

Special issue on winter sports

Peter Federolf · Martin Strangwood

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In all forms of winter sports the equipment is of central importance. The equipment is needed to protect the athlete from adverse environmental conditions and to provide safety and comfort. Moreover, in a majority of winter sports the equipment facilitates a specific form of locomotion: gliding on the snow or ice. Gliding allows for much higher speeds than other, more typical forms of human locomotion, such as walking or running. It is thus the equipment that makes most forms of winter sport the highly dynamic sports that are so appealing to many of us.

Much research has been and continues to be carried out in improving the safety and performance of winter sports athletes through better designed equipment. It is, therefore, perhaps not a surprise that our call for papers for a special issue on winter sports in the journal *Sports Engineering* resulted in an overwhelming response. Nineteen manuscripts were submitted of which 11 were found suitable for the journal. Eight of these could be included in this special edition, and others were distributed throughout volume 17. This editorial provides a brief overview of all accepted papers.

Protection against injury has always been a primary field of interest for researchers and engineers working on winter sports. Two papers submitted for this special issue specifically address injury prevention. A white paper by Michel and colleagues presents current concepts for wrist protectors in snowboarding and discusses the need for an industry standard. This paper represents a position statement of the International Task Force on Wrist Protectors in Snowboarding of the International Society for Skiing Safety (ISSS). Another review paper by Senner et al. focuses on knee injuries in recreational alpine skiing and discusses what modifications of the ski-binding-boot system might offer an opportunity for reducing the risk of injury. The authors specifically consider the implications that the development of mechatronic bindings may have for injury prevention in skiing discussing three different types.

Speed is an important determinant for athlete performance, which places a premium on optimising gliding friction and air drag. Several studies included in this special issue address friction phenomena. Puukilainen et al. used a variety of measurement devices that are currently used in the industry to characterise the surface properties of skis. They document changes in the topography, crystallinity and wettability of the skis' running surface and in the skis' sliding properties due to ski use, waxing and stone grinding. Bardal and Reid investigated how air drag depends on the permeability of alpine skiing apparel. Contrary to common belief, they found a weak dependence implying that increasing apparel permeability may have only a marginal effect on the speed of alpine skiers. Lozowski and colleagues investigated the friction between speed skate blades and ice by developing a sophisticated model that incorporates various interaction processes. To the best of our knowledge, this is the first model for speed skate-ice interaction that considers inclined skate blades. The studies by Swarén et al. and Petrone et al. investigated the deformation properties of cross country ski poles and alpine ski boots, respectively. Both of these topics are important for the performance and the comfort of the athletes participating in these sports.

P. Federolf (✉)
Norwegian School of Sport Sciences, P.O. Box 4014,
Ulleval Stadion, 0806 Oslo, Norway
e-mail: peter.federolf@nih.no

M. Strangwood
The University of Birmingham, Birmingham, UK

Four studies submitted to this special issue describe the development and validation of measurement devices that are needed to characterise the motion and loading of athlete and equipment during winter sports. Using a system of infrared cameras to track the motion of reflective markers attached to an athlete is a state of the art procedure in biomechanical research. Sunlight and reflections from the snow surface present challenges for such systems that can be overcome by specific filtering procedures. Nedergaard et al. determined the measurement accuracy of such a system indoors and outdoors on snow and concluded that three-dimensional motion tracking is feasible and reliable in both conditions. Ohtonen et al. and Hoset et al. developed force transducer systems to determine the ground reaction forces in cross country skiing. Hoset and colleagues used roller skiing on a treadmill as a model for cross country skiing. They instrumented a roller ski to measure the vertical force on the roller ski and used a motion tracking system to determine the direction of this force in an external reference system. Implementation of force transducers in the bindings of actual skis is challenging due to weight and size limitations and due to the internal stresses created when a ski with pre-tension is pressed onto the snow surface and loaded. Ohtonen et al. developed and validated two instrumented cross country ski bindings, one for classic skiing that measured vertical and anterior–posterior forces and a skating binding that measured vertical and lateral forces. In alpine skiing, force plates mounted between ski and binding and pressure insoles placed inside the ski boots are frequently used measurement devices. Force plates can be used to determine the position of the force application point (FAP) on the ski, i.e. the position of the resultant perpendicular force transferred from the skier onto the ski. Pressure insoles are placed inside the ski boot and detect the centre of pressure (COP) under the sole of the foot. A priori these two variables seem related. However, Nakazato et al. quantified the amplitude and the "similarity" of the time characteristics of COP and FAP. In the anterior–posterior direction they found some similarity between COP and FAP but much smaller amplitude in the COP. The lateral positions of FAP and COP showed no systematic relationship. These results highlight how important the ski boot shaft is for the transfer of forces and moments between skier and ski, and thus, for the skier's control of the skiing motion.

We would like to thank all contributing authors for their efforts. This Special Issue provides a cross-section of various research topics in the engineering of winter sports equipment. We hope that it will find interested readers and that it will stimulate further research on winter sports equipment. We and all other editors of Sports Engineering would welcome a greater number of submissions on the topic of winter sports in the future.

Peter Federolf
Guest Editor
Norwegian School of Sport Sciences, Oslo, Norway

Martin Strangwood
Editor-in-Chief
The University of Birmingham, Birmingham, UK