

Irving S. Scher
Richard M. Greenwald
Nicola Petrone *Editors*

Snow Sports Trauma and Safety

Conference Proceedings of the
International Society for Skiing Safety:
21st Volume



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Foreword

The International Congress on Ski Trauma and Safety is a biennial meeting of the International Society for Skiing Safety (ISSS), a community of physicians, engineers, and researchers from universities and technical institutions, skiing professionals (including instructors, patrollers, and competitors), ski resort managers, lawyers, equipment manufacturers, and the general public that share the common mission of improving snow sport safety. The congress is their opportunity to update and report the state of the art of worldwide activities and researches that are oriented to the reduction of likelihood of injuries. The 21st International Congress on Ski Trauma and Safety was held in San Vito di Cadore—Cortina d’Ampezzo, Italy, from 8 to 13 March 2015. This meeting was held in conjunction with the Winter School in Sports Engineering of the International Sports Engineering Association, as an opportunity to merge the activities of the members of both associations.

This collection of the papers is the 21st Volume of Snow Sport Trauma and Safety (formerly the Skiing Trauma and Safety published by ASTM International). The 16 papers in this volume were presented at the symposium and were subsequently accepted for publication following rigorous peer review. This publication is supported by ASTM International Committee F27 on Snow Skiing.

The editors for this publication were Irving S. Scher, Ph.D., P.E., Principal at Guidance Engineering and Affiliate Scientist in the Applied Biomechanics Laboratory at the University of Washington, Seattle, Washington, USA; Richard M. Greenwald, Ph.D., President of Simbex, Lebanon, New Hampshire, USA, and Adjunct Professor, Thayer School of Engineering, Dartmouth College, Hanover, New Hampshire, USA; and Nicola Petrone, Ph.D., Department of Industrial Engineering, University of Padova, Italy.

Peer Review Policy

Each paper published in this volume was evaluated by two peer reviewers. The authors addressed all the reviewers' comments to the satisfaction of the technical editors. The quality of the papers in this publication reflects not only the obvious efforts of the authors and the technical editors but also the work of these peer reviewers. The editors acknowledge with appreciation their dedication and contribution of time and effort on behalf of ISSS.

Preface

The International Society for Skiing Safety (ISSS) was founded by Ejnar Eriksson, MD, of Stockholm, Sweden. After the first World Congress on Skiing Trauma and Safety that occurred in Riksgränsen, Sweden, in 1974, the ISSS was organized. The first official ISSS congress was held 3 years later in 1977 in the Sierra Nevada of Spain. After the 1977 meeting, the ISSS has held its congress every other year at or near a ski resort in many parts of the world. The congress has been held at the following sites: Queenstown, New Zealand, in 1979; Bormio, Italy, in 1981; Keystone, Colorado, USA, in 1983; Naeba, Japan, in 1985; Chamonix, France, in 1987; Riksgränsen, Sweden, in 1989; Thredbo, Australia, in 1991; Zellam Zee, Austria, in 1993; Voss, Norway, in 1995; Whistler/Blackcomb, British Columbia, Canada, in 1997; Breuil Cervinia, Italy, in 1999; Queenstown, New Zealand, in 2001; St. Moritz/Pontresina, Switzerland, in 2003; Arai, Niigata, Japan, in 2005; Aviemore, Scotland, in 2007; Garmisch-Partenkirchen, Germany, in 2009; Keystone, Colorado, USA, in 2011; San Carlos de Bariloche, Argentina, in 2013; and Cortina-San Vito di Cadore, Italy, in 2015. The next congress will be held in Innsbruck, Austria, from 17 to 22 April 2017. The Chair, Secretary General, and Medical Head for this meeting will be Werner Nachbauer, Gerhard Ruedl, and Martin Burtscher.

The objective of the ISSS has been to bring together individuals from many professions to identify, evaluate, and discuss all aspects of safety concerning outdoor winter sports activities. This and previous volumes of *Snow Sport Trauma and Safety* (formerly the *Skiing Trauma and Safety* published by ASTM International) are excellent places to start if one wants to discover what is known about skiing injury and safety. These collections of peer-reviewed papers represent the most significant body of literature in the field. The articles presented in this book represent the effort and opinions of the authors based on their studies, investigations, and sometimes conjectures. It is important to note that many of these papers document research on topics under development. Each paper has been reviewed by peers of the author, meaning that the standard of the presentation and the technical work supporting the discussion are sufficiently high to merit presentation of the author's work, conclusions, and opinions. Publication does not mean that the substance and conclusions represent the opinion of the reviewers, editors, or the ISSS. Most

opinions and conclusions expressed in these papers should be expected to evolve and be clarified in future work.

Over 30 years ago, ski injury research was focused on reducing the incidence of tibia and fibula fractures and researchers believed that the design of releasable ski bindings was the key element to solving the injury problems in skiing. Snow sports and its equipment have changed significantly since that time. Other equipment (such as snowboards and alpine touring ski equipment), injuries (such as knee ligament tears and head injuries), and injury modes (such as landing from snow park jumps) have become the focus of attention. It is now recognized that the likelihood of injury is dependent on the combination of many factors, some of which not yet identified. While a reduction in the snow sport injury rates may be realized with equipment design, other factors may be just as likely to hold the key to this; factors described in the papers in this volume, such as skier behavior and race course equipment design, may be part of the solution. Though empirical evidence provided by injury statistics demonstrates progress in reducing the likelihood of some injuries, these same data show the need for continued attention to other injuries.

The state of the art presented in this collection of papers covers a short list of current topics in skiing research. Areas not covered include the following: national and international snow sport standards; release binding designs and adjustments; ski poles; energy management devices for collisions with fixed objects; snowboards, telemark skis, and other types of skis; helmet, goggle, and clothing design; injuries to the spine, femur, and head; competition safety practices and injuries; fatalities; and other winter sports injuries such as sunburns and hypothermia. There is no topic that has been solved completely and many are not represented in this volume. We urge all who are interested in snow sports safety to contribute to increasing our knowledge in these areas.