



# skiing trauma and safety

FOURTEENTH Volume

EDITORS :  
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# ***Skiing Trauma and Safety: Fourteenth Volume***

*Robert J. Johnson, Michael K. Lamont,  
and Jasper E. Shealy, editors*

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# Foreword

This publication, *Skiing Trauma and Safety: Fourteenth Volume*, contains papers presented at the symposium of the same name held in Queensland, New Zealand, on 5-10 August 2001. The symposium was sponsored by ASTM International Committee F27 on Snow Skiing. The symposium co-chairpersons were Robert J. Johnson, University of Vermont, Michael K. Lamont, ISSS, and Jasper E. Shealy, Rochester Institute of Technology.

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# Overview

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The thirteen articles published in this book were among the 40 papers that were presented at the 14<sup>th</sup> International Conference on Skiing Trauma and Safety, which was held in Queenstown, New Zealand from August 5-10, 2001. This congress, which occurs every other year has been co-sponsored by the ASTM International Committee F27 on Snow Skiing and the International Society of Ski Safety (ISSS) since 1983. The papers published here were submitted by the authors and underwent a rigorous peer review process.

The International Society of Skiing Safety was founded as a result of the 1<sup>st</sup> World Congress on Skiing Safety that was held in Riksgränsen, Sweden in 1974. The organization of the Society was instigated under the enlightened leadership of Ejnar Eriksson, MD of the Karolinska Hospital in Stockholm, Sweden. The second meeting of the society occurred in 1977 in the Sierra Nevada of Spain and has been held biennially ever since. The subsequent meetings occurred in Queenstown, New Zealand in 1979, Bormio, Italy in 1981, Keystone, Colorado, USA in 1983, Naeba, Japan in 1985, Chamonix, France in 1987, Riksgränsen, Sweden for a second time in 1989, Thredbo, Australia in 1991, Zell am Zee, Austria in 1993, Voss, Norway in 1995, Whistler/Blackcomb, British Columbia, Canada in 1997, Breuil Cervinia, Italy in 1999 and Queenstown, New Zealand in 2001. Preparations are presently underway for the 15<sup>th</sup> International Symposium on Ski Trauma and Safety which will occur in St. Moritz, Switzerland from April 27th through May 2<sup>nd</sup>, 2003 under the direction of Dr. med. Georg Ahlbäumer.

The primary purpose of the Ski Trauma and Ski Safety Congress is to bring together a wide variety of individuals interested in all aspects of skiing safety. These meetings have served as a format for the presentation of a multitude of subjects concerning snow sports including the means to prevent injury and improve various aspects of the sport and the treatment of injuries. Initially the prime subjects of interest revolved around snow skiing including alpine skiing and the many variations of cross-country skiing. In recent years with the development of other winter snow sports such as snowboarding, freestyle skiing, skiboarding and other hybrid activities the interest of the society has widened considerably. A major accomplishment of each of these meetings has been the publication of the presentations given during the congresses. Since 1983 with the cooperation of the American Society for Testing Materials (ASTM) International we have published a book containing papers given at the congresses. These publications have continued to be the primary source of information for all of those interested in skiing safety. Following the 1999 and 2001 meetings, abstracts of the papers presented at the Congress were published in *Knee Surgery, Sports Traumatology and Arthroscopy*.

Attendees of the symposia of skiing trauma and safety have included representatives of the skiing industry such as binding, boot and ski manufacturers, engineers from industry, universities and technical institutions, skiing professionals such as ski instructors and patrolmen, physicians, lawyers, ski area managers and participants in recreational and professional skiing and riding activities. Interchange of ideas, comments, and critiques are encouraged in formal discussion of the papers. Many of the individuals who attend these meetings are involved in the ASTM International Standards process or those of other national and international standards organizations and are members of the International Society of Skiing Safety but all interested individuals are encouraged to participate.

All authors who present papers at the meeting are encouraged to submit their papers in a manuscript form to be considered for publication in the Special Technical Publication (STP), which results from the peer review and editorial processes of the ASTM International. We believe that this ongoing effort has produced the standard for the world in the assemblage of a relevant body of literature dealing with safety in winter sports as well as the prevention and treatment of injuries sustained by participants in these activities. The fundamental goal of both the International Society of Skiing Safety and the American Society for Testing Materials International Committee F27 on Snow Skiing is to improve the sport of skiing and associated activities by reducing the risk of injury and producing better and more enjoyable means of participating in all these winter snow sports activities.

### **Summary of Sections**

This STP has been organized into two sections. The first deals with winter sport skiing equipment issues and the second with the epidemiology of injuries resulting from skiing, snowboarding and related activities.

#### *Equipment Issues*

The first paper in this section is by Yamagishi and his colleagues in which they investigate the differences in pressure distribution inside the ski boot when using carving skis or conventional skis. They found that the carving ski resulted in greater pressure distributed in the rear portion of the ski boot during turns than that measured when using conventional skis. They surmised that this may increase the incidence of ACL injury by the Phantom Foot mechanism. Their work implies that better sagittal balancing ability as well as improved edging behavior is required to stay centrally positioned over the ski using a carving ski as compared to conventional equipment.

In their paper, Bruck and his co-investigators present the development of a dynamic model for the performance of carving skis. Information that this model will provide could be utilized to improve binding design and also to determine the side cut shape for energy optimal skiing on various snow surfaces. This they believe will allow improved performance of skiers and thus, potentially make skiing safer, more comfortable and require with less energy expenditure.

Senner and Schaff provide information concerning the possibility of developing release bindings for skiboards. They did a field study with conventional bindings on skiboards to demonstrate the need for potential releases. They believe that twist release at the toe is necessary, due to the occurrences of releases and twists and the high frequency of spiral fractures observed amongst snowboard users. Based on that experience, a computer simulation of a forward fall situation was performed to further examine the need and feasibility of a heel release on skiboards. They found that the upward directed force of the heel would be much lower than in traditional length skis, but that forward release is probably advisable. They felt that it would probably be necessary to develop a new type of binding which allows a "frontal release" rather than to simply use a conventional Alpine binding.

The next two articles in this section complement each other and are authored by Shealy, Ettlinger and Johnson. The first article presents what the authors feel is the present state of knowledge concerning binding function and their relationship to skiing injuries. It has been well established that improved binding function and the application of standard practices developed by ASTM International and the International Standard Organization (ISO) have resulted in a significant reduction of lower extremity injuries in Alpine skiing. However, the incidence of severe knee sprains has not similarly improved and, in fact, it significantly



worsened in the 1980s and has plateaued at a high level in recent years (nearly 20% of all injuries in the U.S.A.). Work presently published indicates that present recommended release values for present day equipment are probably at an optimum. Any attempt to lower these values will probably be ineffective at reducing the injury rate and may actually increase it by resulting in more inadvertent releases. In the companion article, the authors recommend established policies, practices and products, which if appropriately applied could quickly and effectively reduce the risk of most common below knee injuries, which are still being incurred around the world. The authors demonstrate how this can be achieved using ASTM International standard shop procedures and test methods.

The final article in this section, LaPorte and co-investigators provide the readers with a proposed modification of the ISO recommendations for ski binding settings. These authors hope that this method when applied differentially to women and men with lighter weights may be able to reduce the risk of ACL injuries generated in Alpine skiing.

### *Epidemiology*

In this section, seven articles are published concerning various aspects of the epidemiology of winter sports injuries. In the first of this group Ekeland and Rødven present a two-year study evaluating 5362 injuries sustained by Alpine skiers, snowboarders and telemark skiers in Norway. Reported injury rates were in accordance with previous reports from Scandinavia but were lower than those reported from North America. In this multi-center study, Alpine skiers sustained knee injuries at a much higher rate than participants in the other two groups and lower leg fractures were still found to be a problem in Alpine skiers amongst children. Snowboarders were more likely to sustain wrist injuries and fractures and telemark skiers were at the greatest risk of hand injuries.

The next two articles in this section deal with injuries occurring to skiboarders. The first article by Johnson et al. demonstrated that lower leg injuries especially tibia and ankle fractures were sustained at a dramatically higher rate than skiers using conventional Alpine skis. The authors also found that the incidence of ACL injuries was much less on skiboards than on other forms of Alpine equipment. The authors believe that their analysis strongly implies that the unacceptable high risk of lower injury rates associated with skiboards is due to the use of non-release bindings. Greenwald and his co-workers demonstrated in their investigation of skiboard injuries that the overall rates of injuries sustained by skiboarders was relatively low compared to Alpine skiers but that lower leg fracture rates were significantly higher than those using Alpine skiing equipment. In spite of this, the authors do not conclude that the lack of releasable bindings on skiboards was a direct cause of this problem. They felt that the primary reason for the high rate of lower leg fractures was that skiboards were used primarily by young males who have a high risk of sustaining tibia fractures. In the Johnson study, the hypothesis that younger skiers are at a higher risk of sustaining tibia fractures than older participants was disproved. Thus, controversy still exists concerning the cause of lower leg fractures in skiboarders. The readers are encouraged to carefully evaluate the methods of both papers and to come to their own conclusions about these issues.

The fourth paper in this section presents a method of comparing the relative incidence of tibia fractures and anterior cruciate ligament injuries from ski areas all around the world. Presently epidemiology data is difficult to compare due to variations in study design. By simply knowing the numbers of tibia shaft fractures and ACL injuries occurring at any ski area, the authors determined the relative incidence of these injuries. From this information the authors demonstrated a method to determine the relative effectiveness of the ski-boot-binding systems as utilized in various parts of the world. Wide variations were found among the ski areas contributing data for this study. The reason for these differences appears to be

due to variations in application of standards concerning equipment practices and testing and also variations in skiing conditions from one site to another. In an article investigating the effect of ski shape on the occurrence of downhill injuries, Merkur and her colleagues evaluated ski injuries in Australia during the 2000 ski season. The authors found that there was not an increase in overall injury incidence among Alpine skiers who use shaped skis as compared to traditional Alpine skis. However, they did find that specific injuries including medial collateral ligament sprains and injuries to the forearm, wrist and hand were more prevalent among those using shaped skis. On the other hand, they found that the combination of complete tears of the anterior cruciate ligament and the medial collateral ligament of the knee were less prevalent on shaped skis than on conventional skis.

Shealy et al. evaluated the incidence of femoral shaft fractures and tibial plateau fractures in Alpine skiers. Femoral fractures were most prevalent in young adult male skiers. Tibia plateau fractures were more common in older and predominately female skiers. There was no evidence that the incidence of femoral shaft fractures had increased in recent years. However, there was an increase in the incidence of tibia plateau fractures but this could be completely explained by the increase in age of the population at risk. Thus, as the mean age of the population at risk approaches that of the tibia plateau fracture group the number of these fractures in the population has increased.

In the final paper in this section, Heir and colleagues present their observations concerning the prevalence of serious knee injuries in free style World Championship skiers. Thirty percent of the women and twenty four percent of the men had sustained at least one rupture of the anterior cruciate ligament at the time of this investigation. Unlike many other sports, there appeared to be no gender difference in the incidence of ACL injuries amongst participants of free style competition. Many of these athletes were able to return to their sport after sustaining an ACL injury.

### *Concluding Statements*

The inter-relationship between the International Society of Skiing Safety and the American Society for Testing and Materials International has resulted in a unique method for providing a forum for the discussion of problems of skiing safety and the publication of a state-of-the-art book such as this Special Technical Publication. The leaders in many fields concerning skiing safety have taken advantage of the opportunity to present papers, discuss paper applications and to interface with their colleagues at the symposia. Many have also taken the opportunity to contribute to the texts that have been generated from these society meetings since 1983. There can be no doubt that the results of the studies presented in the STPs have resulted in major changes in the skiing industry that have improved skiing safety. The overall skiing injury rate in the early 1970s was over 5 injuries per thousand skier days and that the rate has dropped to below 2.5 per thousand skier days by the early 1990s. More recently we have seen a stagnation, or plateauing of rates for lower extremity injuries. There is reason to believe that a more vigorous implementation of existing standards concerning ski shop practices could result in lower injury rates than currently exist. The vast majority of the improvements in injury rates over the years have been due to the reduction of injuries to the lower extremity. However during the last twenty years we have observed a significant increase in the incidence of severe knee ligament sprains especially to the anterior cruciate ligament. In spite of our ongoing efforts to address this problem ACL injury rates have not improved. It is hoped by continuation of the efforts by all members of the ASTM International and the International Society of Skiing Safety that the improvements in injury rates of the past can be re-ignited. Thus, the prevention of these severe knee injuries must continue to be one of our highest priorities.

Two papers in this text (*What Do We Know From Ski Injury Research that Relates Binding Function to Knee and Lower Leg Injuries and Where Do We Go from Here*) provide a clear road map to how we can improve the injury situation with existing systems and how we can develop even more effective solutions in the future. It is certainly within the purview of our societies to continue to work to use the knowledge we already possess to implement means of mitigating these problems.

We hope that the investigations presented in this text will stimulate not only those of us who have been involved in this process for many years but also encourage new investigators to bring their expertise into the ever expanding field of winter sports safety. We challenge all that have the opportunity to read this text to bring their ideas, methods and expertise into the unique format that is offered by ASTM International and ISSS. We invite all those who are interested to join us in the symposia and challenge you all to help by contributing to the literature on snow sport safety and injury prevention.

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[10] Competitive skiers, high level skiers and ski instructors have 47% likelihood of sustaining a major knee injury during their career. Why is this a problem? This injury can be extremely painful and debilitating, often requiring re-constructive surgery.Â Skiing trauma and safety: fourteenth volume, ASTM STP 1440. West Conshohocken, Pennsylvania, USA: ASTM International. 11. Paterno, M. V., Schmitt, L. C., Ford, K. R., Rauh, M. J., Myer, G. Dâ€¦ The ski radius, the ski length and the standing height on the ski may be relevant ski parameters. For the binding, the release mechanisms in different mechanical degrees of freedom, the impact tolerance and the maintenance frequency are discussed. In the ski boot, the height of the upper, the boot liner, the shaft stiffness, and the position on the ski may play a role. The biggest challenge, but probably also the biggest opportunity for a reduction of knee injury rates seems to be the development of a mechatronic binding. The current strategies to develop these types of bindings are explained by ASTM International. in Skiing Trauma and Safety: Fourteenth Volume. Cited by 9. Skiing Trauma and Safety: Fourteenth Volume pp 113-113; doi:10.1520/stp10965s. Publisher Website. Google Scholar.