

Skiing Trauma and Safety

T H I R T E E N T H V O L U M E



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Skiing Trauma and Safety: Thirteenth Volume

*Robert J. Johnson, Paolo Zucco, and
Jasper E. Shealy, editors*

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Each paper published in this volume was evaluated by two peer reviewers and at least one editor. The authors addressed all of the reviewers' comments to the satisfaction of both the technical editor(s) and the ASTM Committee on Publications.

The quality of the papers in this publication reflects not only the obvious efforts of the authors and the technical editor(s), but also the work of the peer reviewers. In keeping with long-standing publication practices, ASTM maintains the anonymity of the peer reviewers. The ASTM Committee on Publications acknowledges with appreciation their dedication and contribution of time and effort on behalf of ASTM.

Foreword

This publication, *Skiing Trauma and Safety: Thirteenth Volume*, contains papers presented at the 13th International Symposium on Ski Trauma and Skiing Safety held 2–8 May 1999 in Breuil Cervinia, Aosta Valley, Italy. The sponsor of the event was ASTM Committee F27 on Snow Skiing. The symposium chairman was Paolo Zucco, Sport & Promozione, Breuil Cervinia, Italy.

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Overview

The 16 articles published in this book were among the 86 papers presented at the 13th International Conference on Skiing Trauma and Safety held in Breuil Cervinia, Italy 2–8 May 1999. This congress, which occurs every other year, has been co-sponsored by ASTM 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 1st World Congress on Skiing Safety held in Riksgräsen, Sweden, in 1974. The organization of the Society was instigated under the enlightened leadership of Ejnar Eriksson, M.D., of the Karolinska Hospital in Stockholm, Sweden. The second meeting of the society occurred in 1977 in the Sierra Nevadas of Spain and has been held biennially ever since. Subsequent meetings occurred in Queenstown, New Zealand, in 1979; Bormio, Italy, in 1981; Keystone, Colorado, in 1983; Naiba, Japan, in 1985; Chamonix, France, in 1987; Riksgräsen, 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; and Breuil Cervinia, Italy, in 1999. Preparations are presently underway for the development of the 14th International Symposium on Ski Trauma and Safety, which will occur in August 2001 in Queenstown, New Zealand, under the direction of the ISSS's long-term Secretary/Treasurer Michael Lamont of Auckland, New Zealand. 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, improve various aspects of the sport, and treat 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 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 proceedings of the presentations given during the congresses. Since 1983, with the cooperation of the American Society for Testing and Materials (ASTM), we have published a book containing representative samples of the papers given at the congresses. This publication has continued to be the primary source of material for all those interested in skiing safety as well as the avoidance of injury and treatment of injuries sustained in winter sports.

Attendees of the symposia on 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 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 meetings are encouraged to submit their papers in manuscript form to be considered for publication in the special technical publication (STP) that results from the peer review and editorial processes of ASTM. 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 and Materials 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 sports activities.

Summary of Sections

This STP has been organized into four sections. The first deals with skiing and snowboarding equipment; the second with the epidemiology of skiing, snowboarding, and related activities; the third a short section on the biomechanics of the knee; and the final section is a miscellaneous section including a paper on helicopter rescue from ski areas plus a final article on the treatment of a specific knee injury.

Skiing and Snowboarding Equipment

In this section there are five papers. The first by Heir and his co-authors presents their observations of on-slope valuation of release bindings for World Cup freestyle skiers. They showed that the mean setting value for release as indicated on the visual indicator scale of the toe piece of the bindings used by 54 World Cup mogul skiers was 92% above the ISO recommended settings values. They found that the release torque of these bindings was even higher than the indicated setting values by a mean deviation of 15% that decreased to 7% after a single release. It is clear from their work that ISO recommendations apparently are not considered seriously when the release bindings of these World Cup mogul skiers are adjusted.

In the second article in this group, Scher and Mote showed that current binding settings standards allow forces that are far greater than the forces required to ski normally for more than half of the subject sample that they evaluated. They found that the minimum retention settings at the toe piece, for 15 of 30 subjects, were less than 65% of the lateral toe force permitted by ASTM standard F 939-93. They felt that because the current standards do not predict accurately the minimum retention settings for most individuals improvements of the standards are needed. They concluded that the inability of the current settings standards to predict minimum retention settings accurately is a problem that can not be solved by adjusting any or all of the coefficients in the current binding settings standards. For most subjects they could not confirm that minimum retention requirements needed to be increased if these skiers are skiing on steep slopes or in poorly groomed conditions. They felt that their study indicated that measurements of lateral toe and vertical heel force components during a small set of tasks that are similar to low-velocity maneuvers that can be quickly performed on a ski slope would provide the best opportunity to identify the minimum retention settings for an individual.

Gulick and Mote present information concerning the means of developing a learning binding for beginner skiers that uses lateral force at the toe and vertical force at the heel as inputs to predict the release settings in external twists, internal twists, and forward release mode. Using their methods they were able to utilize release settings that averaged 22% less than the corresponding ASTM recommended settings for the three directions mentioned. These reduced settings did not result in inadvertent releases for any of their test subjects during trials of normal skiing conducted during the study.

In their investigation Goodwin and Ford evaluated the influence of many variables in on-snow ski boot pressure measurements. This study compared the effects of many variables

with respect to measurement of kinetic data collected during alpine skiing. Their results were felt to be useful for input for empirical models that could estimate pressure distribution along the running surface of a ski during skiing. They think that alpine ski properties and ground reaction conditions produced by these models could be used to help manufacturers predict ski performance earlier in the design and development stages than is now possible.

In the final paper in this section, Torres and her co-investigators presented an apparatus for measuring mechanical properties of snowboard boot/binding systems in bending. They report that no testing standards have yet been developed for snowboard boot and binding designs nor are there standardized methods for determining the physical properties of boots and bindings. The apparatus they designed can be used to quantify mechanical properties of the boot/binding system. They propose that the data generated from their investigations may be useful in developing standardized tests and a better understanding of the performance of these systems in the field.

Epidemiology

Ekland and Rødven present information comparing differences between winter sports participants in alpine skiing, telemark skiing, and snowboarding. The overall injury rate was 1.2 injuries per thousand skier days or ten thousand lift transports. Alpine skiers accounted for 57% of the injuries in comparison to 34% in snowboarding and 9% in telemarking; 26% of the injuries were to the knee in alpine skiers, 13% in telemarkers, and snowboarders 6%. The percentage of knee injuries was twice as high for females as for males in all three of the disciplines. Snowboarders suffered more fractures than alpine or telemark skiers. Almost half of the injured snowboarder beginners suffered wrist fractures compared to only 14% among the expert snowboarders.

In their investigation Laporte and his co-investigators evaluated a large body of material including some 25,000 ACL ruptures. They noted that ACL ruptures accounted for 9.2% of total injuries for adult males and 20% in adult females. They advocate that there may be a possibility of reducing the risk of injury, especially in females by a 15% reduction in the binding adjustments presently advised by ISO adjustment charts.

In the third article in this section, Johnson and his co-investigators demonstrate that over the last 26 years there has been a significant decrease in lower leg injuries but that the improvement has not continued over the last eleven years. It appears that the lessons learned in the 1970s and the 1980s were not fully implemented in the 1990s. They propose that if present equipment is brought into compliance with relevant standards the declining trend in lower leg injuries may be restored. They have also demonstrated a significant increase in the incidence of ACL injuries over the entire 26-year study period, but there has not been a significant rise in this disturbing trend over the past nine years. As yet there appears to be no effective product, policy, or practice that can reduce the incidence of ACL injuries.

Greenwald and co-workers have done a one-year-study of skiboarding injuries. They find that skiboarding injuries occur at a rate lower than alpine skiing but found that lower leg fracture rates were significantly higher than alpine skiing. They propose that demographics or equipment usage may account for these changes, but they feel that more detailed studies are required to determine if this trend is consistent and if there is a mechanism of lower leg fracture in skiboarding that can be identified and perhaps somehow mitigated.

In a paper on a similar subject involving the new sport of skiboarding, Shealy and his co-authors presented a study involving 16 ski areas that had rental shops with both alpine units and skiboard units. They found that the overall injury rates in these groups were higher for skiboarders than for alpine skiers and that the lower leg injury group was nearly four times higher for skiboarders than for alpine skiers. Unlike Greenwald and his associates in the

previous article, these authors felt that the high incidence of tibia fractures was likely related to the nonreleasable design of bindings used by skiboarders. These authors and Greenwald and his group strongly support continued study to determine more precisely the type and mechanism of injury among skiboarders in order to develop interventions that can help reduce the risk of injury.

In another article by Shealy and his co-investigators, the authors presented their findings concerning the modalities of death in snowboarding and skiing. Between 1991 and 1999 data obtained from the National Ski Areas Association concerning traumatic deaths during the snow sport activity were evaluated. During this time, 28 deaths were reported in snowboarders compared to 257 in skiers. The overall rate of death for snowboarders was 0.46 per million participant visits compared to 0.70 per million skier visits for alpine skiers.

In the final article in this section, Goulet and associates presented an interesting investigation of the relationship between motivation toward alpine skiing, attitude toward risk-taking behavior, risk-taking behavior, and injury incidence. They investigated three groups, including 163 skiers who were observed performing voluntary thrill-seeking behavior on the ski slopes, 190 skiers who were injured in skiing, and 219 randomly selected uninjured skiers. Skiers in the risk-taking group averaged 19.9 years of age, those in the injured group 24.7 years of age, and those in the uninjured group were 30.7 years of age. Skiers in the injured group were the least skilled, while those in the risk-taking group had the greatest skill. There is no difference in the source of motivation for skiing and the attitude towards risk-taking in the injured and uninjured groups. However, skiers in the risk-taking group were significantly different in these variables. They perceive risky behavior as being less dangerous than skiers from the uninjured and the injured groups.

Knee Biomechanics

This next section has two articles. In the first, Freudiger presents a mechanical knee simulator that he believes closely duplicates realistic knee response to skiing and falling loads. With a ski installed on this device's sole, investigations of the ability of bindings to potentially protect the knee from injury can be studied. The author is confident that the use of this simulator may help understand the persistence of the present high injury rate to knee ligaments during skiing.

In the second article in this group, Freudiger and Friederich present their observations concerning various mechanisms of loading of the knee during skiing that resulted in injury. They devised this from literature analysis and their own studies. From this they feel there are two main maneuvers that result in injury. One rotates the ski against the skier's inertia and the second rotates the skier against the ski, which is held fixed to the snow surface. They described four basic groups including flexion, external rotation, internal rotation, and extension and have divided these groups into 17 subgroups that they define as "load cases" that can result in ligament injury. They feel that an understanding of their system may be helpful in future investigations of knee ligament injuries and their prevention.

Specific Problems

This last section also contains two papers. In Cadman's presentation, he investigates complexities of medical evacuations from one major Canadian ski area with the use of helicopters. He gives interesting insights into the methodology of safely carrying out this type of evacuation. He brings out important training issues needed to make med-evacuations by helicopter safe and efficacious.

The final paper of this book is by Yamagishi and his co-workers, who present their observations concerning the surgical treatment of tibia plateau fractures and avulsions of the tibial spine sustained in downhill skiing accidents. They demonstrated that with the use of arthroscopic reduction and internal fixation of these tibial plateau fractures, results could be expected to be as good as with conventional open reduction and internal fixation. Their treatment goals of the restoration of joint congruity and restoration of normal alignment can be obtained satisfactorily with this type of intervention.

Concluding Statements

The interrelationship between the International Society of Skiing Safety and the American Society for Testing and Materials 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. Clearly 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 texts such as this 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 five injuries per thousand skier days and that the rate has dropped to below 2.5 per thousand skier days at the present time. The vast majority of the improvement has occurred due to reduction of injuries to the lower extremity primarily involving fractures and sprains of structures below the knee.

However, during this same period of time 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, we have not made major inroads in solving this problem. It is hoped by continuation of the efforts by all members of ASTM and the International Society of Skiing Safety that the means of eventually finding a solution to this continuing nemesis of the sport of snow skiing will be found. It is clear from the contents of this book that interest is high in this field of endeavor and that, although many frustrations have been encountered, the goal of reduction of these knee injuries is still one of our highest priorities.

We have seen during the course of the collaboration between ASTM and ISSS that winter sports have changed dramatically. The development of snowboarding and skiboarding, both of which continue to increase in popularity, has produced a number of interesting differences in injury epidemiology from those of alpine skiing. It is certainly within the purview of our societies to continue to work to identify the differences and attempt to find means of mitigating these problems.

It has been the purpose of the International Society of Skiing Safety coupled with ASTM to bring to the attention of all those interested in skiing safety that specific research methods must be applied to attain valuable and usable information in ongoing epidemiologic studies. Clearly many of the papers now presented at the meetings and eventually published in STPs show improvement in the knowledge of appropriate epidemiologic methodology. It is only through the use of appropriate techniques that inroads can be made to identify problems present in winter sports and then determine by appropriate interventional methodology that risk of injury can be reduced.

It is hoped that individuals who read this text will be stimulated to further support the efforts of all of us to reduce the risk of injury in winter sports. We hope that the investigations presented here 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 who have the opportunity to read this text to bring their ideas, methods, and expertise into the unique format offered by ASTM and ISSS. We invite all those who are interested to join us in the symposia and challenge all of you to help by contributing to the literature on snow sport safety and injury prevention.

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