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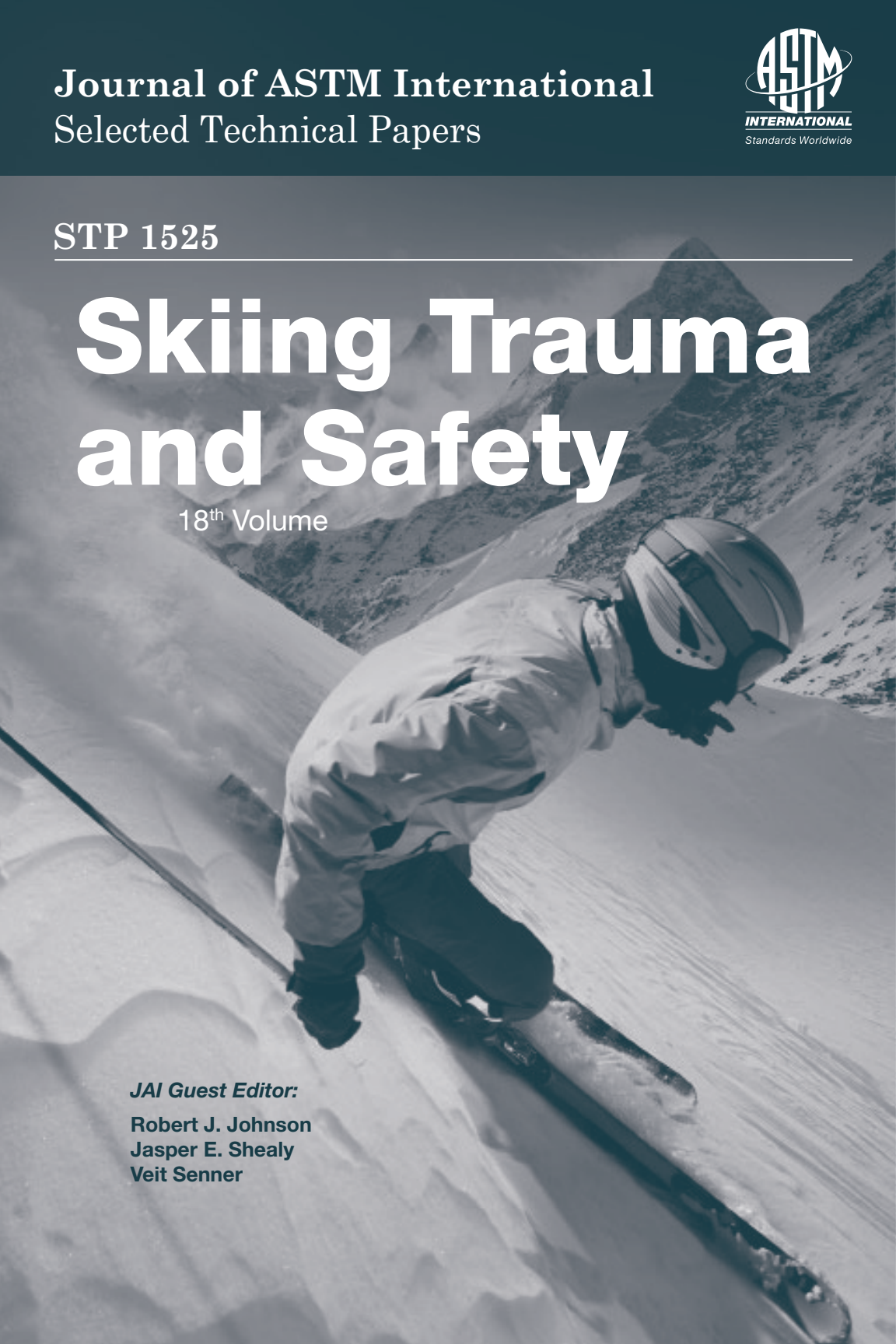
Skiing Trauma and Safety

18th Volume



JAI Guest Editor:

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Skiing Trauma and Safety, 18th Volume

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Foreword

THIS COMPILATION OF THE *JOURNAL OF ASTM INTERNATIONAL (JAI)*, STP1525, on *Skiing Trauma and Safety, 18th Volume*, contains 16 papers published in JAI that were among the 80 papers presented at the 18th International Society of Skiing Safety (ISSS) Congress in Garmisch-Partenkirchen, Germany, on April 26–May 2, 2009. The meeting was sponsored by the ISSS and this publication is supported by ASTM International's Committee F27 on Snow Skiing.

The congress president was Professor Dr.-Ing Veit Senner, Technische Universität München, Institute for Ergonomics, Department of Sports Equipment and Materials, München, Germany. The JAI guest editors were Robert J. Johnson, MD, Emeritus Professor of Orthopaedic Surgery, Department of Orthopaedics and Rehabilitation, University of Vermont College of Medicine, Burlington, Vermont, USA; Jasper E. Shealy, PhD, Consultant and Emeritus Professor of Human Factors Engineering, Rochester Institute of Technology, Rochester, New York, USA; and Professor Dr.-Ing Veit Senner.

Contents

Overview vii

Equipment

Retention Requirements for Alpine Ski Bindings
C. F. Ettlinger, D. Dodge, R. J. Johnson, J. E. Shealy, and M. Sargent 3

Helmet Use and Self-Reported Risk Taking in Skiing and Snowboarding
G. Bianchi, O. Brügger, S. Niemann, and M. Cavegn 32

Evaluating the Performance of Helmet Linings Incorporating Fluid Channels
D. Stewart, L. R. Young, R. Goel, G. Christou, and M. D. Gilchrist 44

Polarizing Filters in Ski Sports
B. Lingelbach and G. Jendrusch 55

Emergency Release for Winter Sports Equipment
W. Schott and V. Senner 65

Behavior

Analyzing the Riding Behavior of Recreational Skiers and Snowboarders
K.-U. Schmitt, P. Niemetz, and M. Muser 79

Reaction Times of Skiers and Snowboarders
E. M. Harley, I. S. Scher, L. Stepan, D. E. Young, and J. Shealy 90

Gender-Specific Effects of Smoking and Alcohol Consumption on the Risk of Falling in Downhill Skiers
M. Burtscher, R. Pühringer, I. Werner, G. Ruedl, R. Sommersacher, T. Woldrich, and W. Nachbauer 99

Hydration Packs Modify Professional Skiers Hydration Levels in All Day Skiing: A Randomized Controlled Trial
G. S. Waddington, T. J. Dickson, S. D. Trathen, and R. D. Adams 106

Epidemiology

Are ACL Injuries Related to Perceived Fatigue in Female Skiers?
G. Ruedl, A. Schranz, C. Fink, E. Pocecco, W. Nachbauer, and M. Burtscher 119

Aging Trends in Alpine Skiing
J. E. Shealy, C. F. Ettlinger, and R. J. Johnson 130

Skiing and Boarding Injuries on Norwegian Slopes during Two Winter Seasons
A. Ekeland and A. Rødven 139

Skiing and Snowboarding Injuries in the Czech Republic in Winter Seasons 2003–2008
J. Rokyta and R. Chlad 150

Biomechanics

Relative Motion of ACL Insertion Points In Vivo: A Case Study, Including Skiing Maneuvers
S. Freudiger, W. Vogt, and D. Wirz 159

Jumper Kinematics on Terrain Park Jumps: Relationship between Takeoff Speed and Distance Traveled
J. Shealy, I. Scher, L. Stepan, and E. Harley, ... **173**

Reaction Forces and Moments in Carved Turns
U. F. Oberegger, P. Kaps, W. Kerber, M. Mössner, K. Schindelwig, and Werner Nachbauer, ... **187**

Author Index **206**

Subject Index **208**

Overview

The 16 papers published in this Special Technical Publication (STP) underwent a rigorous peer-review process and were published electronically prior to the printing of this book in the Journal of ASTM International. The ISSS was founded under the leadership of Ejnar Eriksson, M.D., of Stockholm, Sweden, after the first World Congress on Skiing Safety that occurred in Riksgränsen, Sweden, in 1974. The first official ISSS congress was held three years later in 1977 in the Sierra Nevada of Spain. Since then, the meetings have been held biennially 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 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; Queenstown, New Zealand in 2001; St. Moritz/Pontresina, Switzerland in 2003; Arai, Niigata, Japan in 2005; Aviemore, Scotland in 2007; and Garmisch-Partenkirchen, Germany, in 2009. The planning for the 2011 meeting to be held in Keystone, Colorado, USA, for a second time is well under way. The congress will be held from May 1-7, 2011. It will be chaired by the president of the ISSS, Rick Greenwald, Ph.D., and Irving Scher, Ph.D.

Through all the years of its existence, the objective of the ISSS has been to gather individuals from many professions together for the purpose of identifying, evaluating, and discussing all aspects of the safety of outdoor winter sports participants. Among those attending the congresses have been representatives of the skiing industry, equipment manufacturers, engineers from industry, universities and technical institutions, skiing professionals, including instructors, patrollers and competitors, physicians, lawyers, the general public, and representatives of organizations from all disciplines of outdoor winter sports. Many of the members of the ISSS and other participants that attend the Ski Trauma and Skiing Safety meeting are members of ASTM and other similar standards organizations from around the world.

When the ISSS began in the 1970s, its focus was on the problems associated with alpine skiers, cross-country skiers, and ski jumpers but as time has passed new endeavors such as freestyle skiing, snowboarding, and skiboarding have been added. The format of the ISSS meetings is a five-day program that includes keynote addresses, podium papers, panel discussions, debates, posters, and demonstrations. The goal is to cover all aspects of snow sports safety. There have been 60-80 formal presentations at each of the most recent meetings. An adequate amount of time has always been allowed for discussion so that varying views and interpretations of the many aspects of winter sports participant safety can be heard.

Since 1974, a book generated from the proceedings of each congress has been published. Beginning with the 1983 meeting, held in Keystone, Colorado, an ASTM Special Technical Publication (STP) has been published. Papers presented at the ISSS congress that successfully undergo a rigorous peer-review process are included. In recent years, these papers have been published electronically in the Journal of ASTM International as well. We believe that the relationship between ASTM and ISSS has successfully allowed us to provide a relevant body of literature concerning safety in snow sports activities, which has become the standard for the world.

Summary of Papers

The 16 papers presented in this publication were divided into four categories: Equipment 5 papers; Behavior 4 papers; Epidemiology 4 papers; and Biomechanics 3 papers.

Equipment

Ettlinger and his colleagues theorized that if binding retention requirements were better understood, bindings could be developed which would eliminate excessive retention or conditions associated with known mechanisms of injury of the anterior cruciate ligament (ACL). They developed a device which allowed them to express retention requirements of alpine skiers in terms of load and load position on a virtual ski from measurements taken during actual skiing. From this information, they described how it may be possible with this technology to optimize the overall release/retention capabilities of future bindings.

Bianchi et al interviewed 1,550 skiers and snowboarders concerning the reasons they did or did not wear protective helmets. They found significant differences between the self-reported on-slope conduct of helmet wearers and those who chose not to wear a helmet. They observed that helmeted participants, whether a skier or snowboarder, tended to demonstrate a greater degree of willingness to take risks on the slopes. They felt, more importantly, that other variables such as age, gender, number of falls per day, and years of experience made a far greater contribution toward a persons willingness to take risks while skiing or snowboarding than whether or not they wore a helmet.

Stewart and his colleagues from the Massachusetts Institute of Technology evaluated the performance advantage of incorporating fluid channels into the foam used to line skiing and snowboarding helmets during standard impact testing. They observed that by incorporating a viscous aqueous solution of 30% glycerin into .95 cm channels placed within foam helmet liners that there was a significant decrease in head impact compared to helmets that did not have these fluid channels. Not only was the initial impact reduced, but repeated testing demonstrated an increasing performance ad-

vantage of incorporating the fluid channels. The samples incorporating the glycerin solution reduced the peak head form acceleration after six impacts by 50% compared to those that did not incorporate the glycerin solution. The authors believe that this utilization of fluids within the helmet lining may well be able to reduce the risk of injury compared to standard helmets.

In analysis of polarizing filters in snow sports, Lingelbach and Jendrusch observed the possibility of improving visibility among snow sport participants. The authors noted that there are advantages to using such filters for driving and motor sports, as well as in sailing and angling. They surmised that polarized goggles may lead to fantastic visual experiences because the contrasts are enhanced when the glare is taken out. However, in their analysis of polarizing filters during alpine skiing they observed that the glare coming from an icy patch might be the only hint that there are dangerous sections of slope ahead. Thus, a polarization filter might eliminate or at least reduce this important information. The authors felt that polarizing goggles are fine for most applications but they did not believe that they were good for winter sports activities such as alpine skiing or snowboarding.

Based on the observation that back country skiing or snowboarding may have fatal outcomes if the participants are caught in avalanches, it is important for binding release to allow trapped skiers or riders to swim to the surface of the moving snow. Mechanical binding release is impossible in flowing snow because of the inability to generate torque on the binding. This may lead to an anchor affect that can be fatal to the participant if the ski or board cannot be released from the foot. For this reason, authors Schott and Senner devised an pyrotechnical charge that can affect release of the equipment if the skier finds the binding cannot be released because of entrapment in an avalanche or when the participant finds himself upside-down in a tree well. The authors stress that the pyrotechnical module must be easily removable to allow transportation of the device on airlines.

Behavior

The authors observed that risk and efforts to increase safety relies to some extent on the knowledge of basic biomechanical characteristics of skiers and snowboarders. With this in mind, Schmitt and his co-investigators developed video-based tracking software to analyze the riding behavior of skiers and snowboarders from a remote location. Their methodology allowed for video-based tracking of a large population of recreational skiers and snowboarders. This allowed them to determine riding speed and the turning radius of the observed riders. Their system allowed them to evaluate 6,821 participants. They found that average riding speed ranged from 16-32 kph and this varied depending on the portion of the slope analyzed. The maximum speed that they recorded was 113 mph. They found that the radius of the turns made by the observed riders averaged 6.2-9.3 meters. They believe that the knowledge gained by their system will allow significant input into

the design of slopes and safety equipment. This analysis also allowed them to determine where an intervention such as the application of speed limits on specific areas of ski slopes where crowding and speed appears to be a bad combination.

Harley and co-investigators determined the reaction times of skiers and snowboarders as they crested a hill and were requested to respond to instructions on a sign that was in their path as quickly as possible. They used two high-speed video cameras to capture the movements of each participant. The reaction time was defined as the time between when the sign first came into view and when the skier or snowboarder initiated a response that led to avoidance of the obstacle. The reaction time for skiers was somewhat quicker than for snowboarders at 856 compared to 1,056 milliseconds. The authors believe this data can be used to estimate the limits of performance for an attentive, experienced skier or snowboarder.

The gender-specific effects of smoking and alcohol consumption on the risk of falling in downhill skiers were studied by Burtscher and associates in Austria. They evaluated 1,607 skiers by means of a questionnaire given on five occasions at five different ski areas. Using logistic-regression analysis, the authors found that being a smoker or drinking alcohol during the day of the interview revealed an increased risk of falling, especially in female downhill skiers. The combination of both smoking and the use of alcohol resulted in an increased risk. They hypothesized from their findings that the avoidance of these risk factors could help reduce the frequency of falls and thus the probability of injuries among female skiers.

In a study performed in Australia by Waddington and co-investigators, the researchers studied 33 subjects on two consecutive days. One of these days they had a backpack which allowed for regular hydration during their skiing activities, while on the other day they hydrated as per their normal practice. It was found that there were significantly higher levels of hydration in those individuals who used the hydration packs. It was not clear whether this level of hydration was important in terms of impacting the skills required for safe snow sports activities. The authors believe that this research raises important questions related to access to water by those participating in snow sports. The authors felt that if the effects of hydration (or lack thereof) are continuous, any negative hydration change may be associated with some determination of the level of performance. They felt that this research raised important questions that require further investigation to delineate.

Epidemiology

In a case control study of injured recreational skiers, Ruedl et al found that female recreational skiers have a twofold greater incidence of knee injuries and a threefold higher ACL injury risk than male skiers. It has been postulated that one of the ways to reduce the risk of these injuries is to avoid

fatigue. Sixty-eight ACL injured female skiers and 136 matched controls were interviewed concerning this issue. In addition, skiing ability, self-estimated fitness level, quality and quantity of breaks per run, sleeping quality, group skiing and skill level of those investigated were recorded. The authors found that 81% of the ACL injured skiers sustained their injuries within the first three hours of skiing and about 71% of the skiers felt no fatigue or only a trace of fatigue in their legs at the time of their injury. Thus, it did not appear that fatigue could be deemed a major risk factor for ACL injury. No other factors evaluated showed any significant difference between skiers with ACL injuries and the controls in recreational skiers.

In an analysis of the effect of aging on the production of injuries in alpine skiing, Shealy and associates evaluated trends in skiing injuries over the 1972-2006 ski seasons. During the duration of the study, the age of injured skiers and of the uninjured control population changed nearly identically with both populations aging as time passed. The population was divided into two age groups 55 and over, and 55 and under. Various injuries were grouped into 13 major injury categories in this analysis. Seven of the 13 injury groups showed a lower risk of injury for skiers over 55 compared to the general skiing public. Five injury groups showed no difference during the passage of time. The only major injury group found to be age-related was that of tibial plateau fractures which occurred at a rate 5.7 times higher in the older age group.

In a continued analysis of winter sports injuries on Norwegian slopes, Ekeland and Rødven evaluated a total of 8,149 injuries that occurred from 2006-2008 at 15 major Norwegian ski resorts. The injury data was based on ski patrol reports. Prevalence of fractures was highest among snowboarders at 30%, followed by skiboarders at 27%, alpine skiers at 22%, and telemark skiers at 18%. Fracture of the lower leg was uncommon among snowboarders and telemarkers as compared to alpine skiers and skiboarders. Injured alpine skiers were most prone to knee injuries, while skiboarders most frequently suffered lower leg fractures. Injury to the wrist was most common among snowboarders. The authors observed that those wearing helmets had lower prevalence of head injuries than those without helmets.

Røkyta and Chlad evaluated injuries sustained among skiers and snowboarders at 33 ski areas from 2003-2008 in the Czech Republic. They found the total number of injuries approximated 5,500 per season during their study. They noted an increased prevalence in upper extremity snowboarding injuries as time passed. They also noted a decrease in prevalence of head injuries and all injuries sustained by cross-country skiers and downhill skiers during their investigation. They were able to determine that the overall injury rate at a representative sample of their ski areas was approximately 1 injury per 1,000 skier and snowboarder visits. The injury rate among cross-country skiers was much lower at 0.1 injuries per 1,000 participant visits.

Freudiger et al evaluated the relative motion of ACL insertion points in vivo. The relative motions of the ACL insertion sites were calculated for a hypothesized ACL. The authors applied loads typical of diagnostic tests as well as loads that may well be imparted to the knee during skiing activities. They found that the highest strains within the ACL in descending order included the Lachman test of 13.5%, 20 Nm internal rotation load of 10.6%, and varus valgus knee movements of 6.4%. They confirmed that the Lachman procedure not only produced anterior tibial translation but also an obligatory internal rotation. Stressing the tibia and the femur to produce medial displacement of the tibia resulted in valgus, external rotation and knee flexion. They found that strain measurements of actual fiber bundles revealed lower local strain than do global strain determination using hypothesized ligaments defined between typical insertion points within the related insertion areas.

Shealy and his co-investigators analyzed skiers and snowboarders jumping from two different sized jumping tabletop features in terrain parks. Actual landing distances measured in the field using a video camera were compared to predicted landing distances using ordinary ballistics equations. A total of 280 jumps were evaluated on the two features with 105 involving skiers and 175 involving snowboarders. Although jumpers could have potentially over-jumped the landing area by using excessive takeoff speeds, this was never observed during the testing. Instead, the jumpers used a corrective turn or slowing maneuver during their approach and landed near the sweet spot of the hill, whether they were skiers or snowboarders. It was clear from the investigators analysis that the jumpers goal was not to go as far or high as they could possibly go, but rather to land at or near a specific point in the landing area.

In the final paper, Oberegger and his associates goal was to compute the reaction forces and moments acting on a skier during a carved turn. Elite skiers were analyzed by video analysis with position markers on the skier and the skis. A forward dynamics model was used to simulate the consecutive turns evaluated. With the parameters studied (slope, tracks, segment properties of the body, ski snow friction and velocity of the skier), the effects on joint loads and performance could be investigated. The authors feel that the use of this analysis can be helpful in future analysis of injury mechanisms.

Concluding Remarks

The cooperation of the International Society for Skiing Safety and the American Society of Testing and Materials International has provided a forum for identifying, discussing and developing prevention methodology to help reduce the risk of injury for the participant in outdoor winter sports

throughout the world. It is our goal through the continuation of this process to be even more successful in the future. To achieve this end, we extend an invitation to all those concerned about problems of safety in winter sports to join us as we attempt to reduce the risk of injury for all who participate.

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