Epidemiology of Snowboarding and Skiing Injuries

Nathan K. Endres MD, Robert J. Johnson MD*, Suezie Kim BS, Carl F. Ettlinger MS
Jasper E. Shealy, PhD

University of Vermont, Department of Orthopaedics and Rehabilitation
Burlington, Vermont USA

Author contact: Robert.Johnson@vtmednet.org

Introduction

The purpose of this investigation is to determine the overall rates of snowboarding and skiing injuries and their trends over time and to highlight important differences in injury patterns between snowboarders and skiers.

Materials/Methods

Prospective data using a case control design was collected from a ski/snowboard injury clinic between 1988 and 2005 (17 seasons). An extensive questionnaire was used to determine demographics and experience as well as injury patterns among participants. The diagnosis and treatment of injuries was provided by on-site orthopaedic physicians. Control data was also collected during the same period and the population at risk accurately established.

Results

During the study there were a total 4,258,700 participant visits with 3,524,200 of those being skiers and 734,5000 snowboarders. The presence of snowboarders gradually rose from less than 5% of all participants to a high of 34% in the 2000-2001 season and then dropped to 20% for the last several years. Total injuries observed were 2053 in snowboarders and 8740 in skiers. Injured snowboarders were younger, less experienced and more likely to be male than injured skiers or control participants. The injury incidence expressed as mean days between injuries (MDBI) averaged 358 for snowboarders and 405 for skiers (the lower the number the higher the injury rate). During the first third of the study snowboarders had a higher incidence of injuries than skiers, during the middle third the incidences were similar, but during the final third snowboarders were again at a higher risk of injury. The most common injury for all snowboarders was a radius fracture while for skiers it was a torn ACL in adults and a knee contusion in children. For skiers, the prevalence was higher for ACL and MCL knee sprains, lower leg contusions, thumb sprains and tibia fractures. For snowboarders, the prevalence was higher for wrist injuries, clavicle fractures and all in-boot injuries. Wrist injuries, contusions, sprains and distal radius fractures accounted for 32.1% of all snowboarding injuries (MDBI 1115) and 3.4% of all skiing injuries (MDBI 11747). ACL injuries accounted for 17.3% of all skier injuries (MDBI 2335) and 1.8% of all snowboarder injuries (MDBI 20404). Twenty-three percent of snowboarder injuries occurred in a terrain park compared to 7% of alpine skier injuries.

Conclusions

The percentage of snowboarders has levelled off at about 20% of all participants. Injury rates in snowboarders have increased recently. Wrist and ankle injuries are more common among snowboarders and knee ligament injuries are more common in skiers. Terrain parks have a profound effect on snowboarder injuries.

Injuries In Norwegian Ski Resorts
The Winters 2005 And 2006

Ekeland A[1]* and. Rødven A[2]

[1]Martina Hansens Hospital, Box 23, N-1306 Bærum
[2]Norwegian Ski Lift Association, Bygdøy allé 39, N-0265 Oslo, Norway.

Contact: arekelan@online.no

Introduction

The Norwegian Ski Lift Association has since 1996 conducted a central registration of the injuries occurring in the major ski resorts to survey the injury types.

Material & Methods

The injuries occurring on the slopes of 16 major ski resorts representing about 50% of the ski lift transports in Norway were recorded by ski patrols the seasons 2004/2005 and 2005/2006.

Results

A total of 8130 injured skiers were recorded. The number of skier/boarder days in the two seasons was 5.466 millions, and the injury rate was 1.5 injuries per 1.000 skier/boarder days. Most of the injuries occurred during alpine skiing (58%) and snowboarding (35%), compared to telemark skiing (3%) and skiboarding (4%). 58% of the injuries required physician or hospital treatment. The injury rate for these was 0.9 injury per 1000 skier/boarder days. Many of the injuries were similarly distributed among skiers and boarders, but the following significant differences were observed (P<0.005)

Injury location and type (%)	Alpine skiers	Snowboarders	Telemarkers	Skiboarders
Arm	6	9	4	6
Wrist	5	26	5	5
Thigh	4	2	2	2
Knee	24	7	14	23
Lower leg	10	3	6	15
Ankle	6	4	13	14
Fracture	22	33	26	34
Lower leg fracture	6	1	3	13

The percentage of knee injuries was almost double as high for females as for males in all four disciplines (P<0.001). Lower leg fracture was more common among injured children <12 years (12%) than among teenagers (2%) and adults (3%) (P<0.001). Among injured skiboarders and alpine skiers 35% and 13% respectively suffered lower leg fracture. Most of the injuries were caused by own falls (85%), but collision was more often the injury cause for alpine skiers (16%) than for telemarkers (12%), snowboarders (7%) and skiboarders (6%) (P<0.001). 9% of the injuries occurred off pist, and more of these needed ambulance transport to hospital than injuries occurring at other locations (P<0.001).

Conclusions

Injured alpine skiers were prone to knee injuries. Snowboarders were prone to wrist injuries and fractures, and skiboarders to lower leg injuries and fractures. The percentage of knee injuries among females was twice that of males in all four disciplines, and injured children suffered more lower leg fractures than injured teenagers and adults.

Accidents Occurring in Snow Parks in France

B Audema, JD Laporte, D Constans
Medicins de Montagne, France

Author contact: bernard.audema@wanadoo.fr

Introduction

Ski resorts worked out snowparks to receive snowboarders and freeriders. It is interesting to observe the characteristics of traumatologic accidents that happen in those snowparks, initially created to reduce the risk of collision between skiers and snowboarders.

Methods

An annual report (400 000 cases in the most complete database of the world) done by 52 practitioners (from 29 French winter sports resorts) permits to reveal each season the evolution of specific indicators. A comparative study between injured and witness populations was impossible because we do not know the frequentation of snowparks.

Results of winter 2005

2,8% of winter sports accidents happen in a snowpark. In those accidents, 64,6% of injured persons are snowboarders (7% of snowboarders and 1,3% of the other users are injured in a snowpark).

In the snowparks, for all sports included, we observed :

- More dangerous localizations (chest, skull, spine) than on the slopes : 17,8% → 27,6%
- More wrist fractures : 8,4% → 13,2%
- More dislocations : 3;6% → 6%
- More cranial traumatisms (CT) : 2,3% → 3,2%
- An increased gravity of accidents : 4,6% → 7,1% *Significant results with P < 0,05, Khi2*

In the snowparks, for the injured snowboarders, we observed :

- A lot more dangerous localizations than on the slopes : 20,2% → 25,6%
- Less wrist fractures : 25,1% → 19%
- More ruptures on the anterior cruciate ligament (ACL) : 1,1% → 3,7%
- Same proportion of CT
- An important increase in the hospitalisation rate : 4,1% → 8,4% *Significant results with P < 0.05, Khi2*
- An increased gravity of accidents : 3,6 → 4 (distribution on an analogical scale of gravity quantification, 0 – 10) *Kruskal-Wallis test : P-value < 0,0001*

Conclusions

The behavior of a lot of snowboarders generates an important increase of the risks, as we can see in medias when exposing freeriders exploits. The standardization of snowparks (stratification by level) is actually elaborated by the Syndicat National des Téléfériques de France and by the AFNOR (French association of normalization). Better equipment and formation for the mountain medical staff are crucial for the management of these emergencies in collaboration with the SAMU (public emergency care service).

The FIS Injury Surveillance System (FIS ISS)

T. W. Flørenes [1], L. Nordsletten [1,2], S. Heir [1,3], R. Bahr [1]
[1]Oslo Sports Trauma Research Center, Norwegian School of Sport Sciences, Oslo, Norway, [2] Ullevaal University Hospital, Oslo, Norway, [3] Martina Hansen Hospital, Baerum, Norway

Author contact: tonje.wale.florenes@nih.no

Introduction

Injuries sustained by elite skiers and snowboarders are a cause for concern. Unfortunately, little is known about the injury profile at the elite level. The injury risk in the various disciplines at the World Cup level is poorly documented. The medical committee within the International Ski Federation FIS has recorded injuries in FIS events, but until now the information collected has not been validated. A new injury recording system, the FIS Injury Surveillance System (ISS), was therefore established for all the disciplines within FIS prior to the 2006-2007 season. The objective of the FIS ISS is to monitor injury patterns and trends in alpine, cross country, ski jumping, Nordic combined, freestyle and snowboard, as well as to provide background data for in-depth studies of the causes of injury for particular injury types in specific disciplines. The ultimate objective is to reduce injury rates through suggested changes in rules and regulations, equipment or coaching techniques based on data provided by the FIS ISS.

Design and Methods

If an injury occurs during official training or competition and requires attention by medical personnel in a FIS race, an injury report should be completed. The technical delegates from FIS are responsible for collecting the injury reports, but whenever available, medically trained individuals should be asked to assist on filling out the medical information. The revised injury report contains information about the event, personal information, type of injury, body part injured, severity of the injury, injury circumstances, course and weather conditions, and whether a video is available. Injury reports are collected from all FIS races, although complete data is only expected from the World Cup level. Exposure data is collected through the FIS results database, which contains information on all events and participants, including the number of competitors for each day of competition and official training. Based on the injury and exposure data in the FIS ISS, injury risk can be estimated as the number of injuries per 1000 runs, 1000 jumps and 1000 km skied, as well as per skier day. To validate the data collected by FIS ISS, injuries are recorded prospectively by the medical team of six World Cup nations during the winter season 2006-2007. Also, all athletes on the same teams will be interviewed at the end of the season. These results will be compared to the results from the FIS ISS to assess the accuracy and completeness of the FIS ISS.

Frequencies of Winter Sport Injuries and Their Changes Over a Four Year Period

Jürgen Oberladstätter[1†], Hans-Christian Jeske[1†], Christian Dallapozza[1†],
Alexander Irenberger[1], Rene El Attal[1], Achim von Goedecke[2] and Christian Fink[1].

[1]Department of Traumatology and Sports Medicine, Innsbruck Medical University, Anichstrasse 35, A-6020 Innsbruck, Austria

[2]Department of Anaesthesiology and Intensive care Medicine, Innsbruck Medical University, Anichstrasse 35, A-6020 Innsbruck, Austria

[†] Authors contributed equally to this study.

Author contact: Christian.Dallapozza@i-med.ac.at

Introduction

Scientific literature on skiing and snowboarding injuries shows very inconsistent data on injury frequencies, patterns and "daytime risk of injuries" in these sports. Due to technical development of equipment, demographic changes in the winter sport population, changes in injury pattern and frequencies can be expected.

Methods

We analysed demographics of the injured winter sport population, evaluated frequency and injury patterns and their changes over a four year period. This case series study was performed at a University trauma centre in the Austrian Alps.

Results

11,467 ski, snowboard and tobogganing injuries were evaluated from 2001 to 2005. Injured winter sport participants were predominantly male (60.5%), in the three sport disciplines. Skiers represented the oldest group (male 35.3 (SD±17.7) (2-84) years and females 33.9 (SD±16.7) (2-82) with high rates of lower limb injuries (40.8%). Tobogganers even showed a higher risk (50.8%) for lower limb injuries than skiers, whereas snowboarders mostly injured upper extremities (44.8%).

Conclusions

An overall increase of injuries nor statistically significant changes in injury patterns could not be seen, during the four year observation period. The early afternoon, especially between 2 and 4 p.m. skiers and snowboarders are at highest risk of injuries.

Ski And Snowboard Accidents In Vorarlberg, A Big Winter Sports Area In Austria In The Season 2003/2004. Evaluation Of The Risk Factors

Christoph Westreicher, MD and Karl-Peter Benedetto, MD
Trauma surgery and Sports-traumatology Feldkirch, Austria

Author contact: christoph.westreicher@vol.at

Introduction

The purpose of the study was the evaluation of risk factors for ski and snowboard accidents in all skiing areas within the federal state Vorarlberg, one of the biggest and most important winter sports areas in Austria within the wintertime 2003/2004.

Methods

All together 1386 sportsmen-and women (971 skiers, 415 snowboarders) took part in the study. On the one hand 1002 patients were registered in 4 hospitals by means of the questionnaires which were to be filled during the ambulant or stationary stay independently. On the other hand, 384 sportsmen-and women (286 skiers and 98 snowboarders) were questioned in several skiing areas by an interviewer. Besides, the choice occurred by chance during cable railway trips. This group forms the control group. The grasped data exist of information to the person like age, gender, to sporting skill and training state, to the equipment, snow conditions and runway conditions, accident cause and, in the end, the evacuation. The data processing and analysis took place with the help of the statistics software SPSS.

Results

We could show, that sportsmen, in particular the ski drivers who pursue regularly 2-3 times weekly sport and therefore contribute to their physical fitness, are exposed to a lower accident risk, than that which train once per week ($p < 0.05$, Odds ratio 1.62, CI: 1,14-2,29). It struck that special among the skisport beginners a raised injury risk was to be found $p < 0.05$, Odds ratio 2.90, CI: 1,42-5,93). Were spent more than 28 days in the season on the runway, snowboarders were significantly more injured than ski drivesr ($p < 0.05$, Odds ratio: 2.09, CI: 1,12-3,88). With regard to the equipment we found the following results: Carving ski did not lead to a rise of the accident risk, on the contrary, in the hurt group a significantly high interest went in skiers on classical ski ($p <$drove 0.05, Odds ratio 5.83, CI: 1,38-24,67). By use of rented equipment a clearly lower accident risk appeared with skiers ($p < 0,001$, Odds ratio: 0.38, CI: 0,20-0,58). The missing proper connection release with the fall led to a raised risk with knee, hand and wrist injuries.

Conclusion

On account of the present results we recommend consistent physical preparation for an upcoming ski season or an upcoming winter vacation in particular with adequate training programs specific for sport. The participation in ski courses should be urged especially to skiing beginners urgently to train on the sports device on the one hand and to avoid typical technical mistakes and unterestimate of the alpine area on the other hand. Remarkably, the significantly higher interest was a classical ski in the injured skier's group, this contradicts the current opinion that Carving ski leads to a higher injury risk. Direct comparisons with respect to the results of other studies are still pending and are presented in the conference. The fact that skiers using rented equipment are put out to a lower injury risk and, on the other hand, the missing regular function of the security connections led to a raised risk for knee injuries, hand injuries and wrist injuries, the question suggests after a regularly obliging service.

Latest Epidemiological Updates In Greek Ski Resorts

A. N. Zacharopoulos*, N. Tzanakakis, G. Katsikaris, M. Koimtzis
General Hospital of Amfissa and General Hospital of Veria, Greece

Author contact: docthaz@otenet.gr

Purpose

To examine the incidence and patterns of snow sports injuries in Greek ski resorts.

Material and Methods

In a prospective control study, all the injuries occurring in two ski resorts during the 2004-2006 winter seasons were recorded. A total of 978 injured skiers and snowboarders were recorded. As a control group, 775 uninjured people randomly were questioned directly on the slopes. Statistical analysis was performed using t-test, x^2-test and Fisher's exact test.

Results

The injury rate for the study was 6.05 injuries per 1000 skier days. 72.7% of the injuries occurred in alpine skiing and 27.3% in snowboarding. Lower limb injuries were the commonest among the skiers (43%) and females had a significant higher percentage (59%) than males (39%). Snowboarders sustained more upper limb injuries (49.2%). Contusions and ligament sprains (22%) were commonest among the skiers whereas contusions and fractures (20.5%) were commonest among the snowboarders. Knee (33.1% v 13.3%) and wrist (6.8% v 20%) injuries had statistically significant differences between skiers and snowboarders. Most of the injuries occurred during "free riding" (65%), but collision was more often the second injury cause for skiers (15.6%) and jumps for snowboarders (23.5%). 32% of all injuries correlated with the use of the lifts. 23.4% were injured when skiing/snowboarding with an instructor. Most of the injuries happened at the end of the skiing day.

Conclusions

Despite the high incidence of snow sports injuries in Greece, the patterns and specific rates of injuries are similar to those reported previously in comparable studies. The incomplete education, the overcrowding and the old equipment are some of the reasons of this high incidence. There is much room to update skiing safety in Greece providing safer slopes and adequate instruction.

Snow Sports Injuries In Scotland 1999-2005

Dr Mike Langran[1,2] and Ms Thiruvothiyur Kesavan Manimekalai[2]

[1]Aviemore Medical Practice, Aviemore, Inverness-Shire
[2]Centre For Rural Health, University Of Aberdeen, Inverness

Author contact: mike@ski-injury.com

Purpose of the Study

To report on the injury rates and patterns seen at ski areas in Scotland between 1999 and 2005

Materials & Methods

All individuals injured at the three largest ski areas in Scotland during the three winter seasons 1999/2000 through 2004/05 were included. Individual demographic details and snow sports related parameters were recorded. Control data were collected at random from uninjured individuals. All three ski areas provided their skier day numbers for each season. Data were entered into a Microsoft Access database and then analysed using SPSS 14.0. Factors associated with injury were first assessed by univariate analysis. Factors with a p-value below 0.2 were then included in a multiple logistic regression analysis. Statistical significance was accepted at p values of less than 0.05.

Results

A total of 2974 injuries were recorded and comparative data were collected from 2930 controls. There were no deaths during the study period. The constitution of the on slope population in Scotland was alpine skiers (69%), snowboarders (25%), skiboarders (5%) and telemarkers (1%). Total skier days for the study period was 926,324 giving an overall injury rate for the study of 3.23 injuries per 1000 skier days (309 MDBI). Looking at the injury rate per study year, it has fallen from 3.72 IPTSD in 1999 to 2.24 IPTSD in 2005. The lower limb was the predominant site for injury in both alpine skiing and skiboarding, whereas the upper limb predominated amongst snowboarders. Skiboarding and snowboarding had the highest rate of fractures, whereas sprains were the commonest injury seen in alpine skiers. Amongst alpine skiers who sustained a knee injury, the ski binding failed to release in 67.3% of accidents that lead to damage to the collateral ligaments. Wrist guards were worn by 18.8% of the control snowboarder population but by only 5% of those injured. 56.9% of all wrist injuries occurred amongst snowboarders with less than one week's total experience.

Multivariate logistic regression analysis showed that the following factors were all independently associated with increased injury risk –

- Participant age< 17years [O.R. 1.77, 95% C.I. 1.52-2.06]
- Snowboarding [O.R. 1.76, 95% C.I. 1.51-2.06]
- Not wearing a helmet [O.R. 1.42, 95% C.I. 1.16-1.75]
- First day participant [O.R. 3.85, 95% C.I. 2.97-4.98]
- <5 days experience that season [O.R. 3.14, 95% C.I. 2.60-3.78]
- Taking more than 10 lessons [O.R. 2.86, 95% C.I. 2.26-3.61]

Conclusions

The risk of injury from snow sports in Scotland is comparable to rates seen in other alpine countries, and the overall injury rate has decreased year on year since 1999. Snowboarding is associated with the highest risk of injury and wrist injuries predominate, especially amongst beginners. Wrist guards should be considered part of a standard beginner snowboard rental package. In nearly 70% of all collateral ligament knee injuries in skiers, the binding system did not release. Improvements are urgently needed to reduce the risk of knee injuries amongst alpine skiers in Scotland.

Accident Occurrence During Evening Skiing

Dr. Jan Rokyta*,
Rudolf Chlad
Mountain Rescue Service Krušné hory, Czech Republic

Author contact: jrokyta@seznam.cz

Introduction

The aim of this study is evaluation of specific factors of evening skiing that influence injuries during skiing and snowboarding. Evening skiing is quite popular in all ski resorts in Czech Republic. Its favour is given by location of ski resorts closed to bigger cities.

Material and Methods

The observation was done in 2005-2006 within activity of Mountain Rescue Service in Krušné hory. The overall capacity of 48 km long ski slopes in this area is 32 000 persons /hour. Evening skiing takes place in the ski slopes with overall capacity of 11 000 persons per hour.

Results

There were 770 injuries in the above mentioned period. We were observing 770 injuries in 2006, out of this only 50 were during evening skiing. We expected the risk of injury during evening skiing to be lower.
In our opinion there are following factors participating on number of injuries:

- Worse visibility leads to slower ride.
- Ski route is not ordered again. Asperity of the surface leads to bigger caution of the skiers, ride is slower.
- Skiers come to evening skiing right from their jobs with relaxing purpose, there is no myasthenia.
- Lower temperature leads to change in snow qualit, which takes effect especially in daily temperatures around zero.
- Especially local skiers living in closed towns come to evening skiing – they know local conditions well, level of their skiing abilities is to manage short but not steep slope.
- Because of lower visit rate of the clash between two skiers is less likely to happen. Snowboarders do not prefer evening skiing. Ride in the dark outside the slope in not possible.
- The lit slopes are usually not the difficult ones.

Conclusion

After rating the capacity of ski lifts during evening skiing and time of their running the risk seems to be higher.

Alpine Skier Injury Trends – 1972 to 2006

Robert J. Johnson, MD*, Carl F. Ettlinger, MS, Jasper E. Shealy, PhD
University of Vermont, Department of Orthopaedics and Rehabilitation
Burlington Vermont USA

Author contact: Robert.Johnson@vtmednet.org

Introduction

Improvements in equipment through the years have lowered the incidence of below-knee injuries but have not been able to reduce the risk of severe knee sprains.

Materials/Methods

The medical clinic at the base lodge of a moderately sized Vermont ski area has maintained detailed clinical records since the 1972-73 season. Data on significantly injured patients brought in by ski patrol as well as those that voluntarily presented themselves to the clinic was recorded. Data on non-injured control subjects was also noted. The numbers of skier visits were accurately calculated. This allowed the determination of the mean days between injuries (MDBI) for all types of injuries sustained by skiers.

Results/Conclusions

Between 1972 and 2006 the authors evaluated prospectively 18,696 injuries sustained by 17,197 skiers and reported to the injury clinic operated in the base lodge. During that time approximately 6,830,200 skiers-visits were accrued by the area. The overall injury rate averaged 365 mean days between injuries over the 34 years of the study and decreased by approximately 50% over the period. Lower leg injuries improved the most with an 85% reduction noted. However, there has only been a marginal improvement over the last half of the study. Overall, the incidence of knee ligament injuries didn't change significantly. However, the incidence of minor to moderate injuries did diminish by approximately two thirds while severe knee sprains, usually involving the anterior cruciate ligament, increased very significantly (228%) through the early 90s. Since then, there has been a modest improvement of approximately 30%. In general, the incidence of upper body injuries did not change although upper body lacerations and thumb ulnar collateral ligament sprains improved. The data will include information from the present season which his still being gathered at this time. This will allow us to fine tune the trends as the last several years of data is added to that which we last published in this format in 1997.

Winter Sports Injuries Trends in France 1992-2006: 436.000 cases

JD Laporte[1], MH Binet[2], Constans C Baudru[3]

[1]Medicins de Montagne, Les Angles, France
[2]Medicins de Montagne, Avoriaz, France
[3]Medicins de Montagne, St Sorlin d'Arves, France

Introduction

Each season 8.8 million skiers and snowboarders are on French ski slopes. 150,000 winter sports injuries occur per season. Among those, only 30.1% are transported by ski patrollers but 94% are treated locally without hospitalisation. The "Medecins de Montagne" epidemiological group presents the most important database in the world, with 436,000 cases of winter sports injuries.

Methods

Each winter since 1992, 70 voluntary physicians from 52 ski resorts able to take care of sports injuries and emergency medicine have collected the "injured population". The epidemiological group has also studied a control group thanks to a partnership with the staff of 12 ski resorts. Skier's interviews and counting of participants are realized at the bottom of the slopes. This allows the observation of the evolution of winter sports injuries. It gives information on the habits of the population exposed to the winter sports risks. The injury rate is calculated each season. National prevention campaigns are decided and can be evaluated.

Results

- Incidence rate has increased since 1992 (from 400 MDBI to 355 MDBI in 2004). We observed the stabilisation of the risk in 2005-2006.
- Incidence rate of ACL injuries in alpine skiing has greatly increased from 4292 MDBI in 1992 to 3000 MDBI in 2000. After two years of prevention campaign, we observed the stabilisation of the risk: only 2993 MBDI in 2006.
- Incidence rate of MCL injuries in alpine skiing has decreased significantly from 1916 MDBI in 1992 to 2748 in 2006.
- Knee sprain is the most frequent injury in alpine skiing, especially among women over 25 (21% of all injuries).
- The higher risk of snowboarding compared to skiing is due to the high rate of wrist fractures among beginners (less than 7 days of practice)
- The campaign "skiez casqué", which means "ski with a helmet" has started in 1993. An important decrease in severe head injuries among children under 14 has been observed. The number of children wearing helmets has increased from 15% in 1995 to 72 9% in 2006.

Discussion

- The risk of severe knee sprain decreased during the prevention campaign but no significant statistical link can be made between these two events.
- For the program promoting the helmet for kids, an important diminution of hospitalisation days has been measured. For children under 11, in case of collisions, head injuries decrease from 15% of all injuries in 1994 to 2,6% in 2006.

Conclusion

Thanks to physicians working at the bottom of ski slopes, the French epidemiological group is able to calculate risk and evolution of the injuries through the years. Observing a control group represent a huge work but is absolutely necessary to compare and to conclude on a statistical point of view. More work has to be done to control the efficiency of the prevention campaign or safety measures.

Injury Trends In Norwegian Ski Resorts In The 10 Year Period 1996-2006

Ekeland A[1]* and. Rødven A[2]
[1]Martina Hansens Hospital, Box 23, N-1306 Bærum
[2]Norwegian Ski Lift Association, Bygdøy allé 39, N-0265 Oslo, Norway.

Contact: arekelan@online.no

Introduction

The Norwegian Ski Lift Association has since 1996 conducted a central registration of the injuries occurring in the major ski resorts to survey the injury types.

Material & Methods

The injuries occurring on the slopes of the major Norwegian ski resorts were recorded by ski patrols the 10 seasons 1996/1995-2005/2006.

Results

A total of 31175 injured skiers were recorded. The mean injury rate was 1.4 injuries per 1.000 skier/boarder days. The injury rate increased slightly from 1.2 injuries for the first 2 seasons to 1.5 injuries per 1.000 skier/boarder days for the last 6 seasons ($P<0.001$). Similar observations were made for skiers/boarders who required physician or hospital treatment increasing form 0.8 injuries during the first 2 seasons to 0.9 injuries per 1.000 skier/boarder days during the last 6 seasons. About half the injuries occurred during alpine skiing. Snowboard injuries peaked with 45% of the injuries in the two seasons 2000/2002 and declined to 35% of the injuries in the last two seasons. Telemarking and skiboarding accounted for less than 10% of the injuries. Most of the injury types have remained almost constant during the period, but lower leg fractures have declined from 20% to 13% among injured alpine skiers $\leq$ 12 years ($P<0.002$). The corresponding percentage for teenagers and adult alpine skiers was about 3-4% during the whole period. In contrast, lower leg fracture in children using skiboards increased from 21 to 35% of the injuries in this age group during the last 4 seasons. Most of the injuries occurred on groomed slopes, but an increasing number of injuries are occurring in snowboarder parks increasing from 4% in the 2000/2002 seasons to 20% in the last two seasons ($P<0.001$). The use of a protecting helmet among injured skiers/boarders has increased steadily from 11% to 44% during the 10 years period ($P<0.001$).

Conclusions

The injury rate has been almost constant during the last 6 seasons in Norwegian ski resorts as has the percentage distribution of most of the injury types. Lower leg fractures have decreased for injured alpine skiers $\leq$ 12 years. The use of protective helmets has increased steadily and almost half of the injured skiers/boarders used helmet during the last two seasons.

Epidemiology Of Humerus Fractures In Alpine Sports

Benjamin Bissell, Robert J. Johnson*, Adam Shafritz, Derek Chase, Carl Ettlinger
University of Vermont Department of Orthopaedic Surgery and Rehabilitation

Contact: Robert.Johnson@vtmednet.org

Introduction

The incidence of specifically classified types of humerus fractures sustained in skiers and snowboarders and the risk factors for these particular injuries have not been published. Review of the literature suggests that many prior studies lack sufficient level of capture and documentation of clinical factors. This information is needed in order to evaluate whether it is feasible and/or necessary to implement actions directed towards reducing certain types of injuries. We hypothesized that snowboarders are at greater risk, and that increasing age is a risk factor. We also hypothesized that snowboarders and skiers are at risk for different types of humerus fractures.

Materials/Methods

The medical clinic at the base lodge of a major Vermont ski area has maintained detailed clinical records as well as radiographs of all patient visits since the 1972-73 season. Data on non-injured control subjects was also recorded. All cases of humerus fractures from the 1972-73 season through the 2005-06 season were analyzed.

Results

327 humerus fractures were identified. The mean days between injuries (MDBI) was 24,377 for humerus fractures in skiers and 15,968 in snowboarders (the lower the number the higher the injury rate). Humerus fractures comprised 1.5% of skier visits to the clinic and 2.2% of snowboarder visits. In skiers, 84% of the humerus fractures were proximal, 11% involved the shaft, and 4% were distal. In snowboarders, 45% were proximal, 41% involved the shaft, and 14% were distal. The most common type among skiers was an isolated fracture of the greater tuberosity (33%) while the diaphysis fracture (41%) was the most common in snowboarders. The average age of uninjured control skiers was 29.7 years and average age of a skiers with a humerus fracture was 37.0 years. The average age of the uninjured control snowboarder was 24 years and the average age of the snowboarder with a humerus fracture was 18.9. Among snowboarders, 71.4% of the humerus fractures were left sided while 53.8% were left sided among skiers. The cause of the accident that led to the humerus fracture involved a jump in 5.4% of skiers and 28.3% of snowboarders. Complete results, including risk factor analysis, to be presented at conference.

Conclusions

Snowboarders are 1.5 times more likely to sustain a humerus fracture than skiers. Shaft and distal fractures combined account for 15% of humerus fractures among skiers compared to 55% among snowboarders. The average age of the snowboarder with a humerus fracture was 4.1 years younger than uninjured controls while the average age of the similarly injured skier was 7.3 years older than uninjured controls. Snowboarders were more likely to fracture their left humerus and to be injured by jumping.

Lower Leg Injuries And Fall Mechanisms During Alpine Skiing Practice.

JF Merino*[1], JD Laporte[2], P Joubert[2]

[1]Salomon Sports, Annecy
[2]Medecins de Montagne

Author contact : JD.Laporte@wanadoo.fr

Introduction

Lower limb lesions are frequent at the time of Alpine skiing practice. A certain number of factors are involved:

- Sex, age, level of practice, material factors.
- Fall mechanism, and speed.

A study was conducted during the winter 2005-2006 in French ski resort, Flaine, on 680 people, to check the first results of previous study and to analyze the fall mechanisms.
Purpose of the study: To describe the fall mechanisms and circumstances of the accidents involving a lower limb lesion during Alpine skiing.

Material and methods

680 people were studied in the medical centre of Flaine:
341 controls, and 339 victims of lower limb lesions,
225 injuries could have been potentially prevented by safety ski bindings in relation to the localisation and the type of lesion, or the fall mechanism. This mechanism was studied by face-to-face interviews of injured people and by looking at photographs or drawings of the fall.

Results

We confirm our previous results and those of the literature. 66,2% of the lower limb lesions likely to be protected by ski bindings occurred for women (32,7% of the control group), 7,1% for children up to 10 years (2,6% of the control group) and 12% for teenagers (7,3% of the control group). These results are significant. We confirm also the increased risk of these lesions for the beginners level (15,6% versus 5,3% of the control group) and for the intermediate level (44,4% versus 24,6 of the control group).
The falls, for this type of lesion, occur at a slow speed or when stationary in 44,8% of the cases.
The fall mechanisms could be identified in 89,5% of the cases. They are in 72,3% of the cases a mechanism with a rotation, isolated or combined. There is no significant difference according to the level of practice. We note an important difference according to sex, 71,4% of the lesions by isolated flexions occur in men versus 67,4% of control group, 64% of the lesions by rotation occur in women versus 32,7% of control group.
35,4% of the lesions occur at slow speed or when stationary.

Conclusions

The lower limb lesions likely to be protected by ski bindings while skiing, often occur with a fall mechanism of torsion at low speed or stopped, more often in children and teenagers, and for beginners and intermediate level skiers. Women have a total risk of lesions 2 times higher than men, due to the very high risk of knee sprain.

Collisions On Ski Slopes: Results Season 2005 Of The French Epidemiologic Network

Dr Bernard Audema, Dr Jean Dominique Laporte, Dr Dominique Constans

Medicins de Montagne, France
Author contact: bernard.audema@wanadoo.fr

Introduction

The results of the epidemiologic observation of winter sports risks are the most complete database in the world about winter sports injuries (more than 400 000 cases at the moment). These results are significant if a comparison with a witness group is possible. Thus it can be used to orientate prevention campaigns and to measure the impact of these actions. This system observes the evolution of collisions since 1992.

Methods

A report done by 52 practitioners (from 29 French winter sports resorts) combined with a study of a witness population permits to reveal the evolution of specific indicators (kind of injury, gravity, distribution by sport, age, etc.). Results are stated in MDBI (Mean Days Between Injuries). The risk is measured with the incidence rate which corresponds to the number of ski days between two accidents. The lower is this number, the higher the risk.

Résults

In winter 2005:

- 2 119 collisions against an obstacle
- 16 789 collisions between users (more than 1 accident of 10)
  - 70% against a skier;
  - 21% against a snowboarder;
  - 3% against a snowblader;
  - 10% against another user of the slopes

Since 1992, the risk of collision against an obstacle has been divided by 3. On the other hand, the risk of collision between users had increased since 2001. In this category, collisions between snowboarders are important; children under 11 and adults over 55 have the higher risk. The frequency of cranial traumatisms is 3,25 times greater if it is a collision. The scale of gravity is significant: the hospitalization rate goes from 4,3 % all accidents included to 6,5 % when it is a collision.

Conclusions

Since the last three winters, national prevention campaigns have given two advices to reduce the number of collisions: “priority to downstream skiers” and “control of speed”. About the risk of collision against an obstacle, we will probably evaluate the effect of the improvement of protective devices and slope signs. The gravity of collisions justifies better emergency care equipment and formation for the mountain medical staff and collaboration with the SAMU (public emergency care service).

The Turin Charter on Skiing Safety

Claudio Detogni* (Azienda ULSS20 Verona, IT), Gianmarco Pagani (Azienda ULSS20 Verona, IT), Caterina Polla (Azienda ULSS20 Verona, IT).

Contact: claudio.detogni@ulss20.verona.it

Introduction

Despite the increasing relevance of the phenomenon of skiing and snowboarding accidents there is a general lack of harmonization of prevention measures at every level: regional, national and international.

Objectives

The Turin Charter on Skiing Safety was prepared by a panel of international experts that gathered in Turin on February 5th 2006 in the context of the Olympic Winter Games, under the patronage and coordination of the Olympic Games Committee (TOROC).
The aim of the Charter is to lay the foundations for articulating a common universal vision and implementing global norms and standards for safety aspects for skiing activities in order to reduce the burden of injuries and promote sport activities and their related benefits, and to create incentives for effective injury prevention. It does not intend to lay down new rights with legal value.
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Method 1: diffusion of the Turin Charter

EuroSafe, in coordination with EC co-financed Project Be.Pra.S.A., was appointed to follow the implementation and world-wide diffusion of the Charter. In order to maximise the scientific output, the exchange of data and information among stakeholders in and outside the network in collaboration with the scientific community will be facilitated by means of existing channels such as the European injury database (IDB) and the EuroSafe Newsletter.

Method 2: implementation of the Charter

EuroSafe-BEPRASA network will be useful to identify a permanent group of experts who provide recommendations and due monitoring of the Charter development process. A working group, set at the International Relations Office of Azienda ULSS 20 Verona , Italy – Leader of the Be.Pra.S.A. project - has been collecting comments, recommendations and suggestions on the document.

The Turin Charter Implementation Process will probably end during the next Olympic Winter Games to be held in Canada in the year 2010.

Results

The Turin Charter has been presented to a series of conferences at international level. In terms of promoting the consensus/adoption of the Charter among key stakeholders which will ultimately strengthen the authority of the Charter, till now more than 200 international institutions have been contacted through the EuroSafe-Be.Pra.S.A. network and have been sent the Charter.

Conclusions

Spreading information on the Turing Charter and periodically revising it will allow to achieve the creation of a world wide known and agreed document which represents the common ground on which to identify and implement best practices on skiing injury prevention and safety promotion.

The Effect Of Ski Boots Upon Foot And Ankle Proprioception.

Greg Woolman*, Dip Pod, Dip Sports Med, MHSc, Peter Milburn, Ph D,
School of Physiotherapy, University of Otago, New Zealand
Author contact sportspod@xtra.co.nz

Introduction

Ski boots are designed to fulfil several key tasks. They must protect the foot and ankle from injury; act as an interface between the foot and the ski, and to enhance lower limb movements effectively so that skiing performance is enhanced. Boot discomfort is generally accepted as a part of the sport however prolonged pressure and discomfort from the boot may contribute to impaired proprioception and sensation and effect skier's balance making them more prone to falls.

The aims of this study were:

a) To measure the effect of ski boots upon ankle proprioception.
b) To measure the effect of ski boots upon foot sensation
c) To measure boot comfort in skiers.

Methods

Twelve experienced ski instructors were recruited from Mt Hutt Ski School. A force plate (AMTI) was used to record centre of pressure during a single legged stance test on each leg. Centre of pressure (COP) was recorded at 100Hz for stance tests with the eyes open for 30 seconds.
The subject's sensitivity to vibration on plantar surface of the foot was palpated at 3 regions using a hand-held Biothesiometer. The mean of each of three recordings at each site was used for comparison. For both of these tests each subject was then asked to put on their ski boots and to ski as they would normally and then return for repeat testing at 3 hours and 6 hours after the initial testing. Variables of interest included root mean square (RMS) of COP displacement in antero-posterior (RMSx) and medio-lateral (RMSy) direction and sway area (Area) calculated as the COP 95th percentile ellipse. ANOVA using the general linear model procedure in SPSS software was used to determine the differences between dominant and non-dominant limb at the 3 test sessions. Post-hoc comparisons were made to compare session, foot location, and gender.

Results

There was no difference in sensitivity scores at any of the 3 locations on the foot or for any of the balance scores. Similarly, there were no significant main effects in scores between different trials (start, middle, or end of the day) when collapsed across gender, and although there were differences between trials, none were significantly different using *post-hoc* Sheffe tests. Females had significantly greater sensitivity (lower scores) than males at two locations on the sole of the foot (hallux and 1st metatarsophalangeal joint) and less, although not significantly so, sensitivity at the heel. Similarly, females had less sway than males, although these differences were not statistically significant. Simple correlations showed that sensitivity at different locations on the foot were highly significantly correlated, and not unexpectedly, RMS values of displacement of the centre of gravity over the base of support was significantly correlated in the lateral and antero-posterior directions.

Conclusions

These results indicate there is no significant effect on foot sensitivity that results from wearing of ski boots. However, while this decrease in sensitivity was not statistically significant, these differences could be clinically important in terms of skiers' ability to maintain normal proprioception and kinaesthetic awareness. Further research in this area is recommended.

3-D Range Of Motion Of The Foot And Ankle During Skiing.

Greg Woolman*, Dip Pod, Dip Sports Med, MHSc
School of Physiotherapy, University of Otago, New Zealand
Author contact: sportspod@xtra.co.nz

Introduction:

Despite the popularity of skiing as a sport world wide there is still very little research on foot and ankle biomechanics whilst skiing. Motion within the foot and ankle is critical to ski edge facilitation and edge control with ski boots largely designed to restrict foot and ankle movement.
Whilst injuries to the foot and ankle are relatively low in skiing, movements around this complex may still be implicated in falls during skiing. The development and improvement of ski equipment ought to be quantitative and based around normative data sets. This study presents these data sets on 3-D foot and ankle joint motion in skiing for the first time.

Method

Four female and three male experienced skiers performed a series of linked turns on an indoor slalom course. A Polhemus Patriot® system was used to measure foot and ankle joint motion in 3-D. This system was made portable with the transmitter mounted to the ski and each subject wearing a backpack containing a battery, motion capture unit, and laptop computer. New Atomic carving skis and bindings were supplied for each gender. Each subject was sampled whilst performing two slalom trials for the left and right ankle respectively. ANOVA was used to explore the effects of the variables measured.

Results

Statistical data was not available at the time of this abstract submission. This will however be presented at the conference.

Time point of injury, injury mechanisms and injury situations of ACL ruptures in World Cup Freestyle Mogul skiing evaluated by an international panel of experts

Stig Heir*[1,2], Tron Krosshaug[1], Arne Ekeland[2]
[1]Oslo Sport Trauma Research Center, [2]Martina Hansens Hospital, Norway.

Contact: stighei@online.no

Objective

ACL injuries in Freestyle Mogul skiing still is a major problem. The injury mechanism is unknown and hard to determine even from video tapes. The objective of this study was to have international experts with different background and daily practice regarding knee injuries in skiing, evaluate the time point of injury, the injury mechanism and the injury situation of ACL ruptures in freestyle mogul skiing.

Material and methods

Three groups of international experts with different background / daily practice regarding knee injuries in skiing were asked to evaluate 11 videotapes of ACL injuries from World Cup freestyle mogul skiing. The 3 groups were: 1. Knee experts without particular ski injury experience, 2. Ski experts without medical background, and 3. Ski injury experts with orthopedic or biomechanical background. The video tapes were time coded and analyzed frame-by-frame with 1/25 sec. intervals. The following questions were to be answered: 1. At what time point does the ACL rupture occur? 2. What is the injury mechanism? and 3. Are there any risk factors related to the skier's attitude pre-injury? The results are analyzed statistically by STATA 8 generalized estimating equations with unstructured correlation matrix and robust varians estimator.

Results

The number of proposed time points of injury for each ACL rupture varied from 2 to 5 (mean 3.4). The ski injury experts tended to estimate an earlier time point of injury than the two other groups of experts ($p=0.074$). The number of proposed injury mechanisms for each ACL injury varied from 1to 4 (mean 2.7). The Boot Induced Anterior Drawer mechanism (BIAD) and a BIAD-like mechanism were the injury mechanisms proposed in the majority of cases. Eight of the 11 ACL injuries were believed to have occurred during landings from one of the jumps in the mogul hill. In 6 of the 8 landing injuries the skier was out of balance sideways and / or backwards with the weight mainly on the injured leg at the time of initial contact with the snow.

Conclusion

Analyzing videotapes to determine the injury mechanism of ACL ruptures in freestyle mogul skiing is challenging, and the proposed time point of injury varied among an international panel of experts. The BIAD or a BIAD-like mechanism was proposed to be the injury mechanism in the majority of cases. The ACL injuries occurred mainly during landings when the skier was out of balance and with the weight mainly on the injured leg.

Comparison of Femoral and Tibial Torsion as Predictors of Ski Binding Responsiveness to Strain Across the ACL during Phantom Foot Falls.

Rick Howell
President and CEO, KneeBinding Inc., Stowe, USA

Author contact: rick.howell@kneebinding.com

Introduction

Present ski binding test methods only sense torsion and bending about the tibia. However, when a skier incurs a Phantom Foot fall with "shaped skis", the tips and tails do not "slide-out", thereby generating two lateral force vectors at the tip and tail, that—when resolved into a single force vector—produce a single force located under (or near) the projected axis of the tibia. This resolved vector (f) produces inward-twisting, abduction, backward-bending loading through the lower-leg/knee/upper-leg/hip, where the lever-arm about the projected axis of the tibia (d) approaches zero; and therefore, since T=fxd, torque about the tibia approaches zero. However, during these Phantom Foot falls, when knee flexion is approx 90-degrees, this same force-vector (f) acts laterally at the distal end of the tibia, *over the full length of the tibia*, to produce torque about the femur. Recently, researchers St. Onge and Hagemeister have proven that this same force-vector (f) produces large strain across the ACL that can exceed the elastic limit. Therefore, measuring torque about the femur can be a practical method to predict strain across the ACL during simulated Phantom Foot Fall conditions, especially since torque measurements about the tibia produce no signal during these same conditions.

Methods

A device connects a metallic 50th-percentile human length 'tibia' to an ISO test sole, while the proximal end of the tibia is connected to a metallic 'femur'. A ski is attached, via bindings, to the ISO test sole. The proximal end of the femur is rigidly fixed to a test frame—as during Phantom Foot Falls when the hip reaches maximal inward rotation and becomes locked. Knee flexion is 90-degrees. Torque transducers are interposed, mid-shaft, on the tibia and femur. A backward-bending preload is applied to the aft-portion of the ski to further model Phantom Foot Fall conditions. Quasi-static loads are applied, via a motor driven cable, perpendicularly to the ski, during a succession of tests at a wide-range of points along the length of ski, in ways similar to the ASTM F-504 test method. However, lateral loads are also applied under and near the projected axis of the tibia where the resolved-centroid of a Phantom Foot Fall acts, laterally, into the ski. When these lateral loads are induced into the ski-human-system, the metallic 'femur' is supported in its bending axis, but is de-coupled, rotationally, about its long-axis via rotary bearings attached to the rigid test frame. Three measurands are recorded simultaneously during ski binding release: (1) peak torque about the femur; (2) peak torque about the tibia; (3) peak force applied to the ski; each as a function of position along the length of the ski.

Results

Large femur torque (20 daNm) is generated when a small Phantom Foot Fall force of 25 daN enters a ski perpendicularly under the projected axis of the tibia; while torque about the tibia approaches zero—well below he recommended torsional release values for any skier. Therefore, typical (torsional / lateral toe) ski bindings cannot release, while large torque about the femur—and hence large strain across the ACL—is produced.

Conclusions

During simulated Phantom Foot Falls conditions, traditional bindings produce non-zero femur torque values as predicted in the analytical model—while traditional measurement methods, involving tibial-torque, produce false-negative values that approach zero.

New Alpine Ski Binding that Responds to Strain Across the ACL during Phantom Foot Falls.

Rick Howell
President and CEO, KneeBinding Inc., Stowe, USA

Author contact: rick.howell@kneebinding.com

Introduction

Present ski bindings only sense torsion and bending about the tibia. However, when a skier incurs a Phantom Foot Fall while using "shaped skis", the tips and tails do not "slide-out", thereby generating two lateral force vectors at the tip and tail that produce a single lateral force-vector having a centroid located under (or near) the projected axis of the tibia. This resolved force-vector produces inward-twisting, abduction, backward-bending loading through the lower-leg/knee/upper-leg/hip, where the lever-arm about the projected axis of the tibia approaches zero; and therefore, since T=fxd, torque about the tibia approaches zero. However, during these same Phantom Foot Fall conditions, when knee flexion is approx 90-degrees, this same force-vector (f) acts laterally at the distal end of the tibia, *over the full length of the tibia*, producing large torque about the femur. Recently, researchers St. Onge and Hagemeister have proven that (1) this same force vector (f) produces strain across the ACL that can exceed the elastic limit; and (2) that bindings that allow a ski boot to rotate about a "second vertical axis" that is located near the front of the boot will mitigate strain across the ACL. Therefore, a binding is presented with a second vertical axis near the front of the boot that acts in conjunction with a lateral heel release to mitigate strain across the ACL. Previous lateral heel release bindings suffered from pre-release: the new technology utilizes axiomatic design-engineering principles to mitigate pre-release.

Methods

A ski binding technology has been developed—and is tested—that allows the accompanying ski boot to rotate about a "second vertical axis located near the front of the boot", satisfying the St. Onge findings. The "second *virtual* vertical pivot" is generated by the projected radius of the toe cup of a traditional binding toe piece, acting in conjunction with a non-pre-releasing lateral heel release binding. The technology also employs a "traditional virtual vertical pivot" that is generated by the projected radius of the heel cup of a normal step-in heel unit (allowing traditional lateral toe-piece release in response to torsion about the tibia); and the binding also provides traditional release in response to forward bending moments. The axiomatic design principles of de-coupling are utilized to mitigate unwanted lateral heel pre-release. To verify the technology's effectiveness toward the mitigation of ACL strain, the response is measured via the femur torque method. To evaluate whether the new technology causes adverse side-effects relating to traditional binding functions, the complete DIN/ISO 9462, 8061, and 9465 standard test methods for alpine ski bindings are applied and performed by the TÜV Test Institute in Munich, Germany. Real-world on-slope testing utilizing the "skiability method" developed by Claude Gantet, is also performed to validate the mitigation of unwanted inadvertent pre-release.

Results

The new binding technology (1) produces the predicted response to torque about the femur (which is a "release response" well below the elastic limit of the ACL during Phantom Foot falls); (2) meets the complete DIN/ISO 9462, 8061 and 9465 standard test methods; and (3) mitigates unwanted inadvertent pre-release in the laboratory and in real-world on-slope tests.

Design Of Ski Bindings For Resisting Inadvertent Release

Christopher A. Brown
Mechanical Engineering Department, Worcester Polytechnic Institute,
Massachusetts, USA

Author contact: brown@wpi.edu

Abstract

The objective of this paper is to report on developments in the design of bindings resistant to inadvertent release, i.e, the loss of a ski when there is no risk of injury to the skier due to loads transmitted through the binding. The rate of injuries due to inadvertent release has been cited in one study as declining. Nevertheless, inadvertent release continues to be a serious problem. This year in two slaloms at the World Cup races at Kitzbuhel there were two racers who suffered inadvertent release. For one past world champion, it was his second inadvertent release in as many televised competition slalom runs. Kitzbuhel is one of the most important ski races in the world. While competition service departments make every attempt to avoid inadvertent releases in front of world wide television audiences, including using release settings hundreds of percent above the recommended setting, this problem recurs. Inadvertent release leads to loss of control, which causes serious injuries, including paralysis and death. This work does not deal directly with inadvertent release due to poor recovery from multiple shocks applied at a high rate. The engineering design approach used here establishes a hierarchy where, at each level, the functions required are developed first and then the physical means to achieve them are matched and tested according to how they might be undesirably coupled with the functions and how large a tolerance they allow; the less coupling and the larger the tolerance, the better the design. One part of the mechanical approach taken here is to increase the amount of work to release, for a given release torque. This is accomplished by allowing for increased displacement before release. Unlike current designs, a design is proposed where separate physical components are used to constrain the boot and to allow displacement before release. The testing of bindings resistant to inadvertent release should include measurement of the work to release. This can be accomplished by a pendulum device, although this kind of dynamic impact testing presents difficulties in standardizing and reproducing the physical attributes of the pendulum to achieve reproducibility between labs. A better approach is to measure the displacement during release and to integrate this appropriately with the loads to release. The conclusion is that it is possible to design bindings that have the potential to improve resistance to inadvertent release.

Ski bindings operation and lower leg lesions during Alpine skiing.

*Laporte JD, MD, Binet MH, MD, Joubert P, MD, Fenet N, MD, "Medecins de Montagne", France

Author contact: JD.Laporte@wanadoo.fr

Introduction

During alpine skiing, lower limb injuries are frequent. A certain number of factors are involved:

- Personal factors: gender, age, and level of practice.
- Material factors: Binding adjustment, length of skis, quality of snow.

A study was conducted during the winter of 2005-2006 in Flaine to check the first results and to supplement the analysis of the falls.

Purpose of the study

The working hypothesis is that alpine safety bindings prevent a certain number of lesions of the leg, foot and knee, including sprains, and not only leg fractures.

Material and method

680 people were studied in the medical centre of Flaine, 316 women and 364 men. 225 were identified because the type and location of the lesion, or the mechanism of the fall, potentially could have been protected by safety bindings. We identified 53 MCL, 80ACL, 50 complex knee sprains, 14 tibia fractures, 5 tibia plateau fractures.
Among these 225 injured, the material could be analyzed completely for 129, in particular the type and state of the material and the adjustment and the operation of the bindings. This analysis was compared with 329 controls. The study of no release and inadvertent releases was made according to gender and mechanisms of fall. The distribution of the percentage of difference between the correct theoretical adjustment of fixings according to the standard AFNOR FD and ISO 11088 and the measured adjustment was studied. (Chi 2 and ANOVA).

Results

For women, 76.5% of the cases likely to be protected by bindings did not release for only 3.5% of inadvertent release (5.3% of the controls). For men, 51.3% of no release for 5.3% of inadvertent release (6,1% of the controls). We confirm the very small proportion of inadvertent release and the importance of no releases for women versus men, significant results. The analysis of the adjustments shows that they are significantly higher during no releases compared to relevant releases. The variations of adjustment are not significant for inadvertent release at the toe but significant at the heel, they are too much low. The variations of adjustments on the toe and heel compared to standard AFNOR, are significantly higher for the injured group likely to be protected compared to the control group. It is not the case for the group of patients whose injuries do not depend on this adjustment.

Conclusion

On the whole, for these lesions, we show an important difference in operation of bindings between men and women, with a very important overlap of no release. We confirm the results of our preceding studies showing an unquestionable influence of binding adjustment on leg lesions, especially for women.

Spinal Trauma In Alpine Skiing And Snowboarding: A Six-Year Review from Inselspital Bern, Switzerland

Franz T[1,2], *Hasler RM[2], Zimmermann H[2], Siebenrock KA[1], Exadaktylos A[2]

[1]University of Bern, Department of Orthopedic Surgery, Inselspital, Bern, Switzerland
[2]University of Bern, Department of Emergency Medicine, Inselspital, Bern, Switzerland

Contact: rebecca.hasler@gmail.com

INTRODUCTION

Cerebral and spinal injuries are the leading cause of death and disability in snow sports accidents. Although there are many studies describing ski injuries, data on spinal trauma resulting from snow sports are limited. The aim of this study is to analyze snow sports related spinal trauma admissions to Inselspital Bern, the tertiary trauma center for the top-level ski resorts of the Bernese Alps and parts of the Valais, Switzerland, over a six-year period.

PATIENTS AND METHODS

All adult patients (over 15 years of age) admitted from July, 2000, through June, 2006, were reviewed using a computerized database. From these records, a total of 728 patients injured from snow sports were identified. Severe spinal injuries, defined as spinal fractures, subluxations, dislocations, or concomitant spinal cord injuries, were found in 73 patients. Patients suffering from transient symptoms such as concussion or lumbago were not included. Epidemiologic data and information about neurological symptoms were derived from the database of the Department of Emergency Medicine. Information about fracture type, treatment, and outcome were taken from a similar database of the Department of Orthopedic Surgery.

RESULTS

During the six ski seasons, a total of 73 patients (17 female, 56 male) with severe spinal injuries were referred to the Inselspital. The majority of those severe spinal injuries (n = 63) were related to alpine skiing. All snowboarders with severe spinal injuries (n = 10) were male. The median age of snowboarders was significantly younger than skiers, 22.5 years versus 40.0 years. A total of 148 spinal fractures, subluxations, or dislocations were diagnosed in 73 patients. Thirty-nine patients suffered from injury pattern at two or more levels. The most common site of injury was the lumbar spine. Fatal central-nervous injuries or neurological symptoms occurred in 28 patients (5 snowboarders, 23 alpine skiers).

CONCLUSIONS

The predominantly injured group of patients are young men, whereas snowboarders are affected at a significantly younger age than alpine skiers. Alpine skiers tend to suffer from more severe neurological injuries, which may be explained by accident mechanisms and higher velocities in alpine skiing. Snowboarders are at greater risk of falling backward, resulting in injury pattern located in the lumbar spine. In a majority of cases, injuries are limited to the spine. As in spine trauma the forces mainly involve the trunk, spine protectors are a sensible measure of prevention.

Wearing Snowsports Helmets: Their Potential Effect On Accidents

Othmar Brügger, Swiss Council for Accident Prevention bfu, Switzerland
Contact: o.bruegger@bfu.ch

Snowsports accidents

Skiing is one of the most popular sports pursued by the Swiss population. Due to the high figure of 45,000 people injured every year, the prevention of ski accidents is one of the focal points for the Swiss Council for Accident Prevention bfu in the sports sector. In 15% of cases, injuries sustained while skiing are to the head or neck if a helmet is not worn. Since ski helmets can prevent most of these injuries, the bfu has been promoting the wearing of ski helmets since autumn 2003 in its prevention campaign "Enjoy sport – protect yourself" as an important measure in preventing head injuries.

Helmet-wearing rate

A representative survey (n_{tot} = 2,729) conducted by the bfu revealed that approximately 13 % of skiers were wearing helmets in the 2002/2003 season. Two years later, a second survey showed a helmet-wearing rate of 28 % (n_{tot} = 6,379).

Reduction in head injuries

Out of a total number of 2.2m skiers, 6,750 suffer head or neck injuries, an estimated 75 % (5,063 injuries) of which are in the area protected by a ski helmet. Supposing that no-one wears a helmet: every season, 24 out of 10,000 skiers injure themselves where they could have been protected by a helmet. A ski helmet would prevent approximately three quarters of these injuries. This would mean that, each season, only 6 out of 10,000 helmet-wearing skiers would suffer a head injury. Since around 600,000 skiers were protected by a helmet in the 2004/2005 season, it can be deduced that approximately 1,060 head injuries were prevented. In the 2002/2003 season, in other words before the start of the "Enjoy sport – protect yourself" campaign, almost 500 head injuries were prevented among the group of 280,000 helmet wearers (13 %). The rise in the helmet-wearing rate thus led to an additional reduction of approx. 570 head injuries a year.

Benefits and cost of increasing the ski helmet-wearing rates

When an employee has a skiing accident, this costs the insurance company CHF 7,000.– on average. Head injuries tend to be more serious in nature, so a cost of approximately CHF 10,000.– per case can be assumed. Alongside the direct costs covered by the insurance company, it is mainly the employer who suffers additional costs due to the employee's loss of productivity. These are termed indirect costs and are approximately 2.25 times higher than the direct costs. It can thus be deduced that avoiding 570 skull, brain and other head injuries during skiing reduces the economic consequences of ski accidents by CHF 18m. In 2005, there were 323,000 more people wearing helmets than in 2003. The average ski helmet costs CHF 135.– and has a service life of around five years. This means that skiers have annual helmet buying costs of a total of CHF 8.7m. Every year, the bfu invests approximately CHF 230,000.– in its prevention campaign for the sport of skiing. The total outlay for prevention thus amounts to CHF 9m. Every Swiss franc invested in the prevention of head injuries while skiing is thus contrasted against an economic benefit of more than CHF 2.–.

Conclusions

The surveys on helmet-wearing rates conducted in 2003 and 2005 reveal that an increasing number of snowsports enthusiasts are wearing ski helmets thanks to targeted promotion measures. Calculations show that the rise in helmet-wearing rates can be assumed to have a markedly positive effect on the number of injured persons, which in turn reduces the cost of snowsports accidents.

The aim is to further increase helmet-wearing rates among skiers and snowboarders. This has the dual benefit of promoting public health and reducing economic costs.

(Notice: At the Congress we will present the results of the survey that we'll conduct in Feb. '07 [n = 8'000 Skiers and Snowboarders]. The calculations will be adapted to the new data and explained in-depth.)

Characterization of Head Impact Occurrence in Pediatric Snowboarders

Aaron T. Buck[1], Susan R. Durham[2]*, Richard M. Greenwald[1,3]

[1] Simbex, Lebanon, NH, USA
[2] Dept. of Pediatric Neurosurgery, Dartmouth Hitchcock Medical Center, Lebanon, NH, USA
[3]Thayer School of Engineering, Dartmouth College, Hanover, NH, USA

Contact: Susan.R.Durham@Hitchcock.ORG

Introduction

Traumatic brain injuries are the leading cause of injury-related death among skiers and snowboarders, and recent studies have shown children in particular to be at highest risk. In addition, snowboarders may have risk of head injury 3-6 times higher than skiers. Youth snowboarder participation rates and development of freeride terrain parks have experienced tremendous growth, yet little is understood about what causes the unique pattern of clinical brain injuries that occur during snowboarding.

Quantitative characterization of the injury-causing impacts is essential to development of effective protective equipment and prevention strategies. This research characterizes head impact occurrence in pediatric snowboarders, and examines the effects of age, gender, experience, and terrain choice on head-impact frequency, magnitude, and impact location for this population.

Methods

Snowboarders aged 6 to 21 were recruited from Whaleback Mountain (NH) to wear an instrumented helmet. Subjects included resort visitors and participants in Whaleback's snowboard instruction programs. Participants completed a demographic questionnaire and use survey, and were instructed to wear the helmet just as they would normally. Inclusion criteria are age 6-21, fit size M or L helmets, and able to provide informed consent.

Commercially available Giro Nine helmets (Bell Sports, Santa Cruz, CA) were modified to include Head Impact Telemetry (HIT) System technology (Simbex). The HIT System uses an array of six accelerometers deployed against the head to record head (not helmet) acceleration, and a wireless transceiver to transmit information to a personal computer for analysis. Reported parameters of head-CG acceleration include impact location, magnitude, linear and rotational acceleration components, duration, and time of day. Measurement validation was completed at Simbex using a pendulum test apparatus and Hybrid-III 3-2-2-2 instrumented head and neck. Instrumented helmets were tested and passed ASTM F-2040. Data from each session was downloaded and stored to a HIT System database, and exported for further analysis. Impact experience was characterized as a function of age, gender, experience, and terrain choice.

Results

At the time of this writing, data are being collected and compiled. Data collection is scheduled to end approximately April 1, 2007. A modified and completed abstract will be compiled and submitted in advance of the ISSS conference for inclusion in the conference proceedings (or as an addendum). It is anticipated that the results will provide a novel look at how often, how hard, and where on the head young snowboarders impact during their normal practice of the sport.

Conclusions

To be presented at the conference.

Pediatric Head and Neck Injuries: Evaluating the Influence of Helmets

Irving Scher*[1,2], Darrin Richards[1], Michael Carhart[1], Tack Lam[1]

[1]Exponent Failure Analysis Associates, Los Angeles, CA, USA
[2]Department of Biokinesiology and Physical Therapy, University of Southern California, Los Angeles, CA, USA

Author contact:ischer@exponent.com

Head injuries account for a large number of skiing and snowboarding injuries; head injuries represent approximately 14% of all skiing and snowboarding injuries (US Consumer Product Safety Commission, 1999) and potentially serious head injuries account for approximately 2.6% of all injuries (Josefson, 1998). Furthermore, children are twice as likely as other age groups to sustain injuries to the head, face, and neck (Cadman and Macnab, 1996). Snow sport helmets have been shown to reduce the likelihood of head injuries for one type of fall in adults (Scher *et al*, 2005) and may do the same for children. Because the weight of a snow sport helmet is a greater percentage of head weight for children than for adults, some members of the skiing community have expressed concern that the additional weight of a helmet may increase the risk of serious neck injuries for youths. To date, no study has experimentally evaluated the influence of helmet use on head and neck injury amongst youth skiers and snowboarders. In order to determine if snow sport helmets influence the likelihood of potentially serious head or neck injuries, we conducted a two-part study. First, we measured the speeds of over 150 youth skiers and snowboarders on beginner and intermediate slopes at Mammoth Mountain, California. Second, we used an instrumented Hybrid III 10-year-old anthropomorphic test device (ATD) to determine the head accelerations and neck loads associated with two types of on-slope collisions: (1) a torso impact without head contact, and (2) a backward fall onto the occiput. Each of these collisions was tested with and without the ATD wearing a helmet. For these tests, the ATD accelerated to the speeds measured during an on-slope study of youth skiers and snowboarders. The ATD impact system used a custom-built pendulum to replicate the fall kinematics found in our previous study (Richards *et al*, 2007) and to simulate fixed object strikes. Preliminary data show that the neck loads did not increase with helmet use in either the torso impact or backward fall conditions. Furthermore, helmet use reduced substantially the linear accelerations, angular accelerations, and head injury criteria (HIC) associated with head-to-ground contact on hard, icy snow. These findings indicate that helmets can mitigate head-to-ground contact severity associated with common fall scenarios without increasing the likelihood of serious neck injuries. The full set of results will be presented at the conference.

Kinematics of a Snowboard Fall: Implications for Snowboard Helmet Testing

Darrin Richards[1], Irving Scher*[1,2], Michael Carhart[1]

[1]Exponent Failure Analysis Associates, Los Angeles, CA, USA
[2]Department of Biokinesiology and Physical Therapy, University of Southern California, Los Angeles, CA, USA

Author contact:ischer@exponent.com

A study by Nakaguchi and Tsutsumi (2002) previously showed that 68% of all snowboarder head injuries were associated with backward falls, where beginner and intermediate boarders constituted the majority of injured patients. In order to facilitate head injury and helmet research, an indoor test apparatus was fabricated that replicated the fall kinematics of a snowboarder during a back edge trip or "opposite-edge phenomena." A Hybrid-III anthropomorphic test device (ATD) was accelerated to a typical intermediate snowboarder speed as defined by Scher *et al.* (2006) and the back edge of the board was snubbed on a mound of snow resulting in a backward fall. This test apparatus produced repeatable (and realistic looking) fall kinematics under realistic on-slope conditions. However the size and cost of this test apparatus would render it prohibitive at most research and testing facilities. In this study, we determined the components of impact velocity of the head in order to simulate the important elements of a head impact during an "opposite-edge-phenomena" fall. Digital high-speed video recorded at 500 frames per second and commercial motion tracking software were used to quantify the snowboarder kinematics throughout the fall sequence: (i) prior to the trip; (ii) during trip phase (i.e. back edge snub); (iii) during free fall; and, (iv) at ground impact. Pre-fall translational energy of the ATD was rapidly converted to a combination of linear and angular energy during the trip phase. Although the speed of the ATD at its center of gravity decreased during the trip phase, preliminary data shows the absolute speed of the head increased by approximately 30% as a result of the induced angular rotation. However, at snow surface contact, the speed of the head normal to the slope was considerably less than the absolute velocity of the ATD's head. This study quantified the fall kinematics for the "opposite-edge phenomena" using a full-scale ATD and better defines the conditions needed to replicate real world head impacts during snowboard falls. The full set of results will be presented at the conference.

Do Helmets Decrease The Incidence Of Death Or Only Alter The Cause Of Death?

Jasper Shealy *, Rochester Institute of Technology, Rochester, NY, USA
Robert J. Johnson, University of Vermont, Burlington, VT, USA
Carl F. Ettlinger, Vermont Ski Safety, Underhill, VT, USA

Author contact: jeseie@rit.edu

Introduction

As of the end of the 2004/05 season, US skier and snowboarder overall fatality incidence rates remain unchanged for the past 14 seasons despite a growth in helmet utilization by the general population from essentially 0% to 33.2%. Helmets have been recommended by a variety of experts as a means of reducing fatalities amongst skiers and snowboarders.

Materials/Methods

A careful screening of Internet news services, and other sources have obtained information on recent individual fatal incidents in skiing and snowboarding in the US. These data have been compared to aggregate annual reports of fatal incidents by the National Ski Areas Association (NSAA) in terms of overall numbers. NSAA conducts an annual Demographic Analysis of Skiers and Snowboarders that provides information on helmet utilization and alpine resort utilization.

Results

The overall rate of death for skiers and snowboarders has shown no trend up or down for the last fourteen seasons. Preliminary analysis of fatality data for three recent seasons (2002/03, 2003/04, and 2004/05; n=104) suggests that the helmet utilization rate amongst the fatally injured is approximately 40%; the helmet utilization rate of the cohort group (younger adult males of average or better than average ability) most likely to sustain a fatal injury is also about 40%. Helmet use clearly affects the primary cited cause of death, but does not seem to decrease the overall risk of death appreciably. Most fatalities are the result of multiple injuries. For those not wearing a helmet, some type of head injury is cited 63% of the time. For those wearing a helmet, a head injury is cited only 35% of the time.

Conclusions

Clearly the use of a helmet results in a different distribution of primary cited causes of death. It is equally clear that there has not been a decrease in the overall incidence of death. In order to more fully address this issue, our study group is obtaining more definitive information as to helmet utilization and causes of death for the three seasons that include 2002/03, 2003/04 and 2004/05. We are expanding the database to include the most recent 2005/06 season.

Snowboarders attending a ski field medical clinic with and without wrist guards: The rate and types of wrist injury seen in these groups.

Dr Tessa Pirie. MB ChB
Staff grade in Emergency Medicine at the Royal Infirmary of Edinburgh, and ski field doctor at Turoa Accident and Medical Centre, Mt. Ruapehu, New Zealand.

Author contact: tessapirie@hotmail.com

Introduction

Snowboarding is very popular and makes up an estimated 38% (72,000) of all snow-users in NZ. A common mechanism of injury in snowboarding is falling onto an outstretched hand (FOOSH). This mechanism has been responsible for the high number of wrist injuries sustained by snowboarders. There has been a recent increase in wrist guard use to prevent wrist injuries in snowboarders. Worldwide figures suggest 10-20% of snowboarders now use wrist guards. This study aims to find the impact wearing wrist guards has on the rates and types of wrist injuries seen in snowboarders attending an on-site ski field clinic with any injury.

Method

The study took place at the Turoa Accident and Medical Clinic, Mt. Ruapehu, New Zealand, during a 4 month period between 18/06/2006 and 19/10/2006. The data was collected on the medical forms for each patient attending the clinic. Epidemiological data on gender, snowsport and wrist guard use was collected. The patients were diagnosed by two experienced emergency doctors with radiological facilities. The wrist injury outcomes were categorised as: 1. Wrist sprain, 2. Isolated distal radius fracture, 3. Colles-type wrist fracture, 4. Scaphoid fracture (clinical and radiological).

Results

A total of 837 patients were seen in the clinic during these dates. 466 (56%) were snowboarders.
0f the snowboarding patients attending the clinic, 332 (71%) did not wear wrist guards, while 134 (29%) wore wrist guards.
153 (33%) female snowboarders attended, 53 (35%) wore wrist guards, while 100 (65%) did not wear wrist guards.
81 (10%) of all patients attending the clinic had wrist injuries. 69 (85%) of these patients were snowboarders.
49 (71%) out of the 69 snowboarders with wrist injuries had no wrist guards, while 20 (29%) did have wrist guards on.
12 (55%) out of the 22 female snowboarders with wrist injuries had no wrist guards, while 10 (45%) did have wrist guards on.
The number of snowboarders with wrist injuries and no wrist guards on had the following injuries: 15 sprains (68% of total sprains in snowboarders), 12 radius fractures (66%), 5 scaphoid fractures (60%), 19 colles-type fractures (78%).

Discussion

Snowboarders attending the clinic with any injury and those with a specific wrist injury had the same rates of wrist guard use. Female snowboarders had a greater rate of wrist guard use if they were attending for a wrist injury than if they were attending for any injury. Wrist injuries in snowboarders with wrist guards on were marginally less severe. An international standard for wrist guards is required to maximize the prevention of wrist injuries in snowboarders.

French prospective study evaluating the protective role of all kind of wrist protectors for snowboarding.

MH Binet Centre Medical Avoriaz 74110 France.
C Girard-Martel Universite de Sherbrooke Quebec Canada.
M Kieffer Centre Medical Medival Val d'Isère France.

Author contact : binet@mdem.org

Introduction

Snowboarding is one of the largest providers for wrist injuries, especially for beginners and teenagers. The risk is calculated each season by the epidemiologic French group Medecins de Montagne. The mean day between injuries (MDBI) for wrist fractures is 1135 for global snowboarding population and reaches 499 for the group 10 to 15 years old. Wearing a wrist protector in France is not so common because it is the case for only 8.9% of all snowboarders. However, more than 6% of the injured snowboarders with a broken radius in our preliminary study wear a wrist guard. At the time of this first study, we did not investigate about the exact type of protection worn, so we could not conclude on an eventual difference in preventive aspect or danger of different type of wrist protectors.

Methods

The actual prospective study started at the beginning of the 2006/2007 winter season. Twenty physicians trained to take care of ski traumas from ten different French ski resorts were participating. Two groups are separated, one with injuries of the upper limb and one with other injuries, this last category represents the control group. We analysed the type of wrist protector, the injury mechanism and the severity of the injury.

The items of the description of the wrist protectors are:
- type: separate wrist guards or splint included inside gloves or mittens
- stiffness: soft or hard
- length: short or long
- position: palm, dorsal or double

The mechanism of the accident is required:
- is it a fall on the hand/wrist or another impact?
- what was the position of the wrist: flexion or extension?

The analysis will cross these different items between them and also with those like age, sex and snowboard ability. We hope to be able to conclude on the real effect of each type of material. This could help to describe snowboarding wrist protectors standards that do not actually exist.

Results/conclusions

The first results of the study will be provided during the congress of Aviemore in May 2007

A novel wrist protector for snowboarding

Aaron T. Buck[1], Robert. W. Rediker[1], Daniel S. Leonard[1], Joseph Gwin[1], Jeffrey J. Chu[1], Richard M. Greenwald[1,2]
[1] Simbex, Lebanon, NH, USA
[2]Thayer School of Engineering, Dartmouth College, Hanover, NH, USA

Author contact: rgreenwald@simbex.com

Introduction

Wrist fracture is the leading cause of injury among snowboarders, with fracture rates as high as 1.02 per 1000 boarder days and up to 3x increased risk for first time snowboarders. Despite inherent risks, adoption rates of wrist guards for snowboarding are quite low; only 7% of injured wore protective guards due to comfort and functional shortcomings such as: limited range of motion, difficult donning, doffing, and adjustment, and poor integration and compatibility with snowboard gloves. Additionally, commercially available wrist protection may not provide effective protection during high energy impacts that can occur even at modest trail speeds.

To address these market needs, a novel method of wrist protection has been devised that affords superior impact protection performance at high impact energies, and enhanced comfort, range of motion, and functional integration to encourage adoption.

Methods

An angular-displacement based restraint system was developed using composite fiber engineered textiles (CFET) to allow free range of motion during normal use (through 30° wrist extension) and progressive lock-up restraint (30° - 65° extension) to prevent terminal wrist extension. The CFET restraint was also used in parallel with rate-dependent damping materials to provide even more effective dynamic performance.

Impact performance of the restraint system and competitive commercial offerings was tested using an instrumented surrogate arm and drop test fixture at Simbex. Measured variables of wrist joint angle, angular acceleration, and drop pad reaction force were used to derive wrist torque and total work performed by the guard. Univariate Analysis of Variance (ANOVA, $a = 0.05$) was used to compare results.

Results

Significant differences in wrist torque, angular displacement, and total work as a function of drop height and guard type were observed. Mean wrist torque for all trials of the CFET guard was 1022N-m, significantly lower than for the Burton Red guard (1209N-m, $P=0.028$) and Serius Jam Master guard (1413N-m, $P<0.001$). Mean work passed through the guard to the wrist was also lower ($P<0.001$) for the CFET guard (153J) than for the Burton Red, Flexmeter, and Serious Jam Master guards (244J, 242J and 321J, respectively). Significantly lower ($P<0.001$) maximum wrist extension angles were also observed for the CFET guard (65° vs. 78.4°, 77.6°, and 81.1°, respectively).

Conclusions

The CFET wrist guard performed significantly better in drop tests than leading commercial guards, lowering maximum wrist extension, wrist torque, and leak wrist loading at selected drop heights. Complete results and discussion will be presented at the conference.

Optimal design of a novel anti-slip pad to improve safety in snowboarding

Böhm H., Souckova M., Senner V.

Technical University Munich, Faculty of Sports Science, Department Sport Equipment and Materials, Munich, Germany

Author contact: boehm@sp.tum.de

Introduction

Snowboarding differs from downhill skiing in many respects. The most important difference is that snowboarders ride with both feet fixed by non-releasable bindings to a single board. Therefore knee injuries are less pronounced than in skiing, since the one leg cannot be twisted with respect to the other. But four to 8 percent of snowboarding injuries take place while the person is waiting in ski-lift lines or entering and exiting ski lifts (Davidson and Laliotis 1996, Calle and Evans 1996). Snowboarders push themselves forward with a free foot while in the ski-lift line, leaving the other foot locked on the board placing a large torque force on this leg and predisposing the person to knee injury if a fall occurs.Various types of anti slip pads are commercially available. They are placed in the middle between both bindings and simple friction between board and boot helps to steer the board. However steering during the backside turn might need additional toehold in vertical direction. Therefore we developed an anti-slip pad with an additional rim at the toes providing vertical grip at the frontal toes. The rim is shaped to cover the tip of the lateral front part of the boot, and it proceeds along the lateral side of the boot. Different positions of the rim and the general acceptance of the rim are not known, so that the aim of this study is to test individual estimation of steering ability of different anti-slip pad prototypes during exiting ski lifts.

Methods

Forty subjects (26 males, 14 females, 17 ± 3 years) assigned to three different levels: beginner advanced and experts, took part in the study. The subjects gave their informed, written consent prior to starting the experiments. The subjects had to perform a paired comparison of different rim positions. In prototype B the foot is standing in a neutral 0° - position perpendicular to the direction of the board. The angle of type A is rotated 20° so that the toes are pointing towards the front of the board. Type C is aligned at -20°. The fourth type (D) has no rim; it represents a commercially available anti-slip pad. To limit time between paired comparisons of the different types, a lift simulator was used. The simulator consists of a seat mounted mobile on two descending rails. The seat is first accelerated by gravity and is then retarded to simulate exiting. After leaving the seat, the subjects have to make either a forward or backward turn to come to rest.

Results and Discussion

For the front side turn and for all subjects tested, the type B was preferred to all others. The type with the least ratings is type D without rim. For the backside turns type C is the most preferred, marginal followed by type B., whereas the ratings are different for the proficiency level, the type without rim was always rated the last. Therefore the new anti-slip pad with an additional rim aligned 20° to the back is most accepted among the subjects tested to improve individual estimation of steering ability during exiting ski lifts and might help to decrease snowboard injuries.

The Design of Releasable Snowboard Bindings

Christopher A. Brown
Mechanical Engineering Department, Worcester Polytechnic Institute,
Massachusetts, USA

Author contact: brown@wpi.edu

Abstract

The objective of this paper is to explore and clarify the functions, rationale, and design solutions for snowboard bindings. If there are injuries that can be prevented or reduced, they will be difficult or impossible to discover through epidemiological work, since there are so few releasable snowboard bindings in use. Epidemiological studies are useful for prioritizing the type and severity of injuries with nonreleasable bindings.

Currently, there are two kinds of releasable snowboard bindings on the market. Both manufacturers claim low injury rates on their equipment. While this is difficult to substantiate, it does suggest that there are benefits to releasable bindings. It is proposed that there are two approaches that can be taken to reducing snowboarding injuries with releasable bindings. One is to interrupt or filter potentially injurious loads that are transmitted through the binding to the leg. This is the approach widely used in conventional ski binding technology. The epidemiological studies show that there are far fewer injuries of this type in snowboarding than in skiing. Some mechanism that would protect each leg individually would eliminate the need for the dual release feature that has been mentioned. Another approach is to have the binding release in order to change the kinematics off the fall. The intent here would be to reduce upper body injuries. Epidemiological studies show that this kind of injury is common in snowboarding. It is proposed that one mechanism that causes this kind of injury is catching an edge, applying an impulse to the rider's feet, so that the edge of the board stops, the rider rotates about the edge, and the rider's upper body is propelled at high speed toward the snow surface. A shear release -- before sufficient impulse could be applied to the feet to cause the rotation -- would reduce this kind of injury. This paper shows possible design solution to provide these kinds of release functions. In addition, the concern about inadvertent release is also addressed. The conclusion is that it is possible to design snowboard bindings with the potential to reduce specific injury mechanisms.

A Review Of Research Literature Relating To An Adjustable/Releasable Snowboard Binding.

Jasper Shealy*, Rochester Institute of Technology, Rochester, NY, USA
Robert J. Johnson, University of Vermont, Burlington, VT, USA
Carl F. Ettlinger, Vermont Ski Safety, Underhill, VT, USA

Author contact: jeseie@rit.edu

Introduction

An active discussion has begun recently on the merits of an Adjustable/Releasable (A/R) binding for snowboarding participants. The release function of alpine ski bindings is intended to address mid-shaft tibial bending and twisting injury mechanisms, and has proven to be quite effective in the mitigation of such injuries. To date, in spite of numerous requests to the advocates and manufacturers of A/R snowboard bindings, no one has specifically enumerated the injury mitigation strategies associated with an A/R snowboard binding.

Materials/Methods

This review of the research literature is intended to be as complete a review of the peer-reviewed research (in English) as possible. Approximately relevant 30 papers are included in the review thus far. We have requested from advocates for A/R snowboard bindings any technical/scientific information (even if not peer reviewed at this time) that they may be aware of that would be of assistance in evaluating the proposition that an A/R binding for snowboarding would result in an increase in safety for snowboarding participants. To date, there has been no response to this request.

Results

The currently available English language peer reviewed scientific literature indicates that snowboarding participants experience a lower rate of tibial shaft injury than is the case for skiers. This is true even though virtually all snowboarders utilize a non-releasable system and virtually all skiers utilize a system designed to release in a manner intended to reduce the likelihood of a tibial shaft injury. The incidence of ankle injury in snowboarders has decreased by approximately 75% since the mid 1980s; the remaining ankle injuries may be more related to ankle support issues and manner of landing than from a lack of a release mechanism. The presence or absence of an A/R binding does not appear to be related to the incidence of Non-Avalanche Related Snow Immersion Death events.

Conclusions

If the intended injury mitigation strategy for an A/R snowboard binding is similar to that of the alpine ski binding, then there does not seem to be a significant problem to be addressed. If there is some other injury mitigation strategy for the proposed A/R snowboard binding, we are unable to discern what that strategy might be.

The Effect Of Binding Stance Position Upon Foot And Ankle Joint Motion During Snowboarding.

Greg Woolman, Dip Pod, Dip Sports Med, MHSc, Peter McNair, Ph D,
School of Physiotherapy, Auckland University of Technology, New Zealand

Author contact sportspod@xtra.co.nz

Introduction

The effect of snowboarding stance position upon the kinematics of the foot and ankle are largely unknown despite the significant stance variations available. Stance set-up would seem more of an art than a science and is based upon the type of snowboarding a rider prefers as well as their own anatomical variables. Earlier research has already highlighted excessive values of foot eversion and external ankle rotation during snowboarding. Three different stance positions were compared with the hypothesis that a neutral stance position would cause more foot eversion and ankle external rotation than more open stance positions.

Methods

Eleven experienced snowboarders performed a series of linked turns on an indoor slalom course. Each subject performed two trials using 3 different stance positions – neutral (0°, 0°), alpine (21°, 6°), and duck (18°, 18°) angles of the front and back feet respectively. New identical boots were provided for each subject. A Polhemus Patriot® system was used to measure ankle joint motion in 3-D of the front foot. This system was made portable with the transmitter mounted to the snowboard and each rider wearing a backpack containing a battery, motion capture unit, and laptop computer. ANOVA was used to explore the effects of boot type on the variables measured.

Results

The mean ranges of motion for various foot and ankle angles across subjects and turns are shown in Table 1. With the exception of foot eversion statistically significant differences ($p < 0.05$) were recorded for all other variables. The greatest differences were highlighted for the alpine stance (21°, 6°) with this position recording higher values for ankle external rotation, ankle eversion, and ankle flexion compared to either neutral or duck stance positions. Alpine stance recorded more than twice the amount of external rotation than the other stance positions.

Table 1: Foot and Ankle Ranges of Motion (means)

Stance position	**Ankle Flexion**	Std Error	**Ankle Extension**	Std Error	**Ankle Eversion**	Std Error	**Ankle Inversion**	Std Error
Neutral	14.70 °	.652	-5.90 °	.751	-9.10 °	.472	2.44 °	.627
Alpine	17.61 °	.652	-2.89 °	.751	-12.12 °	.472	-0.21 °	.627
Duck	15.84 °	.652	-3.90 °	.751	-10.17 °	.472	1.94 °	.627

Stance position	**Ankle Int Rot**	Std Error	**Ankle Ext Rot**	Std Error	**Foot Inversion**	Std Error	**Foot Eversion**	Std Error
Neutral	5.06 °	.541	-5.60 °	.539	-1.74 °	.317	-8.96 °	.431
Alpine	1.32 °	.541	-11.58 °	.539	-2.33 °	.317	-9.42 °	.431
Duck	5.60 °	.541	-5.60 °	.539	-1.86 °	.317	-9.51 °	.431

Conclusions

There are statistically significant differences between stance positions. The results support our earlier findings on foot and ankle motion during snowboarding, however were contrary to our hypothesis that the neutral stance position would allow more ankle external rotation. Compared to the neutral and duck stance positions the slalom stance (with the front foot angled more toward the tip of the board) does allow for more rotational motion particularly external ankle rotation. Ankle flexion angles for the front foot were lower than expected however foot eversion was greater than expected for all three conditions despite not being statistically significant. It would appear that the foot maintained this pronated position throughout all of the trials. When considering flexion, eversion, and external rotation movements that have been implicated in ankle injuries in snowboarding, it would appear that the more commonly adopted slalom stance position may in fact predispose to ankle injuries. Further research is required in testing stance positions during more extreme snowboarding.

Computer Simulation of a Combination of Carved Turns

Martin Mössner[1](*), Dieter Heinrich[1], Peter Kaps[2], and Werner Nachbauer[1]
[1] Department of Sport Science, University of Innsbruck, AT
[1] Institute for Basic Sciences in Engineering, University of Innsbruck, AT
Author contact: martin.moessner@uibk.ac.at

Introduction

Towards the aim of simulating turns of a skier we investigated the track of a rigid sledge on two skis through several turns. A model of the sledge and the skis was implemented in the simulation software LMS Virtual.Lab. For the ski-snow contact a hypoplastic constitutive equation was used. For shearing orthogonal metal cutting theory was applied. The simulation model was validated in the case of a single turn. There the edging angle and the center of mass position of the sledge were fixed (Mössner et al. 2006). To complete consecutive turns the edging angle had to be adjusted. For a stable movement of the sledge the force vector resulting from weight and centrifugal force had to be supported by the area between the two skis. The purpose of this study was to improve the model in order to simulate a combination of turns and to perform parameter studies with the improved model.

Methods

For simulating turn combinations we implemented driver elements for edging angles of the skis and the position of the center of mass of the simulation model. Data of the edging angle were taken from field measurements. Additionally we did parameter studies for the turn combination obtained above. We varied ski properties, such as bending and torsional stiffness as well as the mounting point of the bindings. Furthermore we assessed the influence of forward/backward leaning by moving the center of mass to the front/rear of the sledge.

Results and Conclusions

The simulation model could be successfully used to simulate the track of the sledge in a turn combination. In parameter studies we investigated the influence of changes in model parameters of the simulation model on the computed path of the sledge. Regarding the variation of the stiffness data of the skis the largest effects were obtained for changes in stiffness of the forebody of the ski. This results from the fact that the shovel digs into the track and the afterbody of the ski glides along the track. Further results concerning binding position and forward/backward leaning will be presented at the conference.

Acknowledgment

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Modern Ski Equipment Does Not Adequately Consider The Vulnerability Of The Female Knee

Werner Nachbauer[1](*), Hannes Gatterer[1], Markus Flatz[1], Gerhard Ruedl[1], and Martin Burtscher[1]
[1] Department of Sport Science, University of Innsbruck, AT
e-mail: martin.burtscher@uibk.ac.at

Introduction

The aim of this study was to identify whether the introduction of carving skis has altered injury rates and/or the gender-specific number of knee injuries.

Method

In the winter season 1997/98, when carving skis began to appear on the ski market, all injured skiers requiring evacuation or medical treatment in 70 Austrian ski areas were collected. Five years later, when most skiers were using carving skis, ski injury data were collected in a representative sample from the first study.

Results

In 1997/98, a total of 17914 injured alpine skiers were recorded. One injured skier per 22,105 ski lift transportation required evacuation from the slope. 29.5 % of the injured male skiers and 53.0 % out of the females suffered knee injuries. In the winter season 2002/03 one injured skier per 24,458 ski lift transportation required evacuation and 27.9 % of the injured male skiers and 51.0 % of the injured female skiers suffered knee injuries. Female carving skiers not using newly adjusted bindings had a higher risk of knee injury than female carving skiers with newly adjusted bindings.

Conclusion

The introduction of carving skis reduced the overall incidence of severe ski injuries but the number of knee injuries remained high especially in female skiers. Along with preparatory strength and proprioceptive training adequate binding adjustments should help to reduce knee injuries in female carving skiers.

An Evaluation of Perceptual Experience of Skiers Using Quantitative Image Processing

David A. Krauss[1], Daniel H. Lieberman[1], Erin Harley[1], Helene Grossman[1], Irving Scher*[1,2]

[1]Exponent Failure Analysis Associates, Los Angeles, CA, USA
[2]Department of Biokinesiology and Physical Therapy, University of Southern California, Los Angeles, CA, USA

Author contact: ischer@exponent.com

Weather and lighting conditions significantly influence the visibility of outdoor settings. In natural environments that are not covered in snow, features (such as grass, dirt, and rocks) provide textural cues and areas of high visual contrast that serve to assist an observer in successfully navigating the environment. Conversely, in a snow-covered environment, the ground and ambient features will be mostly white. When there is sufficient ambient sunlight, individuals can perceive contours of the ground because sunlight is reflected off the surface at different angles and to different degrees depending on the exposure and slope of the contours on the hill. When the sun is obscured by clouds or other environmental features (often called flat-light), ambient light becomes more uniform and the slope characteristics then become less distinguishable. Under conditions where slope characteristics are less distinguishable, a higher probability of injuries may arise. In the present study, we applied the principles of visual perception, light, and optics to quantify the influence of ambient sunlight on the ability of skiers and snowboarders to perceive ground contours on a ski slope. To this end, we systematically measured the visibility of the terrain on ski runs under a variety of lighting conditions at Mammoth Mountain in California, USA. Recreational skiers, snowboarders, and ski patrol members were surveyed to determine their subjective ratings of visibility. Using these subjective visibility ratings for various weather/lighting conditions, we will quantify on-slope visibility using the quantitative contrast and luminance measurements. The methodology presented in this paper provides a first step in using a software-based image analysis as a tool to predict the likelihood of injuries under different lighting conditions. Ultimately, resorts could use this data to develop methods of enhancing visibility on poorly lit runs before injuries occur.

Percepted risk and experienced flow in mogule skiing: easy bump areas as a safety measure?

Tanja Felder[1], Thomas Brandauer[2] and Veit Senner[1](*)

[1] Technical University Munich, Faculty of Sports Science, Department Sport Equipment and Materials,
Munich, Germany
[2] University Klagenfurt, Institute of Sports Medicine, Department Sport Psychology, Klagenfurt, Austria

Author contact: senner@sp.tum.de

Skiing resorts have changed. Whereas thirty years ago a number of mogul runs were part of every important resort today the majority of pistes are extensively prepared. Bump pistes have lost their attraction and are mainly limited to steep terrain where slope preparation cannot be realized. Tremendous improvements concerning equipment (carving skis, snowboards), the preparation of skiing slopes and the absence of mogul runs of variable difficulty are the main reasons for this development. This study analyses the topic from a motivational perspective. A questionnaire based on Csikszentmihalyi's (1975) flow-concept was administered to n=890 skiers and snowboarders. The results show that 31.9% of the participants are not attracted by bump pistes and they usually avoid them at all means. N=399 skiers (all levels) answered the questionnaire immediately after skiing down a mogul run of medium difficulty that was exclusively provided for the purpose of the study. A statistically significant correlation ($p<0.01$) was found between the quality of the achievement and the intensity of the experience. The better the assessment of one's achievement the more intense and positive was the assessment of the corresponding experience. Advanced skiers mastered the run remarkably better than beginners and they assessed the experiences more positively ($p<0.01$). The results support Csikszentmihalyi's flow-hypothesis that an even match between the environmental demands and an athlete's skills is an important prerequisite for positive experiences. Moguls in easy and moderate terrain don not seem to overstrain the skiers; instead they are providing a challenge, which is positively attributed. Easy mogul runs within the slope area are therefore providing additional attraction to skiers without having them to go off-piste.

Csikszentmihalyi, M.(1975). *Beyond boredom and anxiety.* San Francisco

Kinematics of ACL injury mechanisms: a side glance at football

Thomas Grund[1], Ina Reihl[1], Tron Krosshaug[2] and Veit Senner[1](*)

[1] Technical University Munich, Faculty of Sports Science, Department Sport Equipment and Materials, Munich, Germany
[2] Oslo Sports Trauma Research Center, Norwegian University of Sport and Physical Education, Oslo, Norway

Author contact: senner@sp.tum.de

Introduction

The rupture of the anterior cruciate ligament (ACL) is one of the most serious and far reaching injuries in skiing. Typical injury mechanisms such as the "phantom foot" or the BIAD (boot induced anterior drawer) are well investigated – in theory. But the estimation of real occurring kinematics during the injury situation is extremely difficult, if not impossible. The same problem exists for non-contact ACL-injuries in football where somewhat similar injury mechanisms as in alpine skiing have been detected. The introduction of new research methods based on the detailed analysis of TV recordings by the use of computer programs provides the possibility the get a deeper understanding of what happens during such an injury situation.

Materials and Methods

Three non-contact ACL-injury situations (2 "plant-and-cut"-manoeuvres, 1 uncontrolled one-leg landing situation) that occurred in German elite soccer league have been analysed using the Poser method (Krosshaug and Bahr (2004)). For this the existing TV pictures with at least three different camera-perspectives have been synchronised and loaded into the software Poser (Curious Labs, Inc., Santa Cruz, CA, USA). There the manual matching of a human skeleton model into the injured player has been conducted. The analysis of the Poser-data has been performed by the use of Matlab r2006b (The Mathworks Inc., Natick, MA, USA). Afterwards the kinematic data has been compared with the results of the Poser analysis of two alpine skiing injuries (Krosshaug et al., 2006) and with well-established data of the literature.

Results

Detailed results of the kinematics of ACL-injuries in football will be presented at the conference as well as comparison with data of ACL-injuries in alpine skiing.

Conclusions

The awareness of the real occurring kinematics of ACL-injuries is the first step towards a more detailed understanding of what is happening during such a situation. Furthermore it is possible to use the kinematic data as input for several computer-models to get an idea which forces are acting inside the human body. Provided with this knowledge effective counteractive measures such as an electronic ski binding could be developed that might prevent people from suffering serious injuries.

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Analyzing the laterality of ACL injury in alpine skiers: Why is the left knee more susceptible to the injury?

Yukio Urabe, Hisao Iwamoto, Koji Miyashita, Sentaro Koshida, Rieko Sasaki, Kosuke Tanaka
Graduate School of Health Sciences, Hiroshima University
1-2-3 Kasumi, Minami-ku, Hiroshima 734-8551 Japan

Author contact: yurabe@hiroshima-u.ac.jp

Introduction

It is well known that alpine skiing is at higher risk of anterior cruciate ligament (ACL) injury than any other sports. Some study has indicated the left knee is more susceptible to ACL injury than right knee. However, what behind the laterality of ACL injury has been a matter of debate. Alpine skiing requires repeating bilaterally-symmetric turning on down hill, though asymmetric pattern could take place in the turning skill. This may be somewhat responsible for the laterality of ACL injury incidence. The author believes that understanding of the mechanism of left ACL injury will advance the current concept of ACL injury prevention in alpine skiers.

Materials/Methods

Study 1
Subjects were outpatients who visited Hiroshima university hospital for ACL injury between 1994 and 2004. Relationships between injured side, injury mechanism and turning side at the moment of injury were examined. Injured side of ACL was also researched in different sports.

Study 2
Twenty recreational skiers who had no histories of ACL injury participated in the study. Isokinetic knee strengths, reaction time measured with single-leg standing were compared bilaterally. In addition, video analyses were performed to measure knee valgus angle during jump landings and knee, hip, and trunk kinematics during a trunk turning test.

Results

Study 1
ACL rupture was confirmed by MRI in 340 patients. 194 of left ACL (57%) and 146 of right ACL (43%) were observed. Prevalence of left ACL injury with right turn was significantly greater than the other cases. Left ACL injury was also greater in handball, basketball, and volleyball players, whereas right ACL injury was more prevalent in Judo.

Study 2
All subjects were right-hand dominant. Strengths of quadriceps and hamstrings appeared to be lower than right; however, statistical significances were not found. Reaction time also appeared to be longer in the left knee, yet no significant difference was found. There were no significant differences in any knee kinematics during the jump landings or trunk turning test.

Conclusions

Left ACL injury with right turning was the most prevalent in the ACL suffered alpine skiers. High prevalence of left ACL injury was also observed in other sports. It is noteworthy that equipment use in alpine skiing may be associated with the laterality. Alpine skiers with no history of ACL injury did not show any laterality in knee strengths, reaction time, and knee kinematics.

Safe ski jump design

Mont Hubbard* and John Kockelman
Sports Biomechanics Laboratory
Department of Mechanical and Aeronautical Engineering, University of California, Davis, California, USA

Author contact: mhubbard@ucdavis.edu

Introduction

Over the last decade the skiing industry in the USA has changed markedly. Recent increases in the proportion of snowboarders have led to development of terrain parks and acrobatic skiing now plays a larger overall role in recreational skiing. To accommodate typically younger and more adventurous sliders, many terrain park features involve jumps but little effort has been spent understanding their safe design and use. This paper presents a design and use methodology for safer ski jumps.

Methods

What goes up must come down. At landing the skier (treated as a particle) velocity vector is changed nearly instantaneously. Its component parallel to the slope remains but the perpendicular component v_p is brought to zero by large slope contact forces. Impact severity is measured by the magnitude of the impulse $I=m*v_p$. The more nearly parallel to the slope the impact velocity vector, the smaller its perpendicular component v_p and the less impulse is required, yielding a safer landing. Because impulse is not easily understood, a simpler impact severity measure is Equivalent Fall Height (EFH), defined as fall height in 1 g environment that results in v_p. EFH has been used to characterize ski jumping impacts (Mueller, 1997) and also in governmental safety measures and standards (NASA, OSHA).

EFH has three parts ($EFH = h_1+h_2+h_3$); $h_1=v_o\sin\theta/g$ is the maximum height of the skier's path above takeoff, where θ and v_o are takeoff angle and speed, respectively; h_2 is the vertical distance of impact below takeoff. With impact on a horizontal slope, component $h_3 = 0$. More generally, h_3 is positive or negative, when the landing slope is positive or negative, respectively. When $h_3 < 0$ it can nearly completely cancel contributions h_1 and h_2 and result in a safe, low-impact landing.

The safe jump design problem can be stated as follows: What should the takeoff angle θ and the snow slope surface y(x) be to subject the skier to a limited (safe) EFH? This design constraint results in a differential equation for the snow surface y(x), whose solution indeed limits EFH to the required value. The paper discusses effects of various parameters on slope design and EFH.

Results

To be presented at the conference

Conclusions

Ski jump landing slopes can be designed and managed to limit skier exposure to safe EFHs. An explicit design and use methodology is presented that results in the shape y(x) for the safe landing slope.

Reference

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Speed Model for Terrain Park Jumps: Designing for Safety and Implementing Scientific Standards

Heather M. LaHart, Worcester Polytechnic Institute Student, (USA)*
Dan Delfino, Worcester Polytechnic Institute Student, (USA)

Author contact: lahart99@yahoo.com

Introduction

The integration of park & pipes into the snowsports industry has come fast and with little guidelines or instructions. The Professional Ski Instructors of America (PSIA) has developed a Freestyle Teaching Curriculum Task Force to teach freestyle related techniques and NSAA partnered with Burton and started a program called "Smart Style" which provides information and signage for Terrain Park, freestyle, and pipe features. Although there have been safety precautions and awareness programs administered by ski areas and parks, there exists no scientific analysis or standards by which terrain parks are built and operated. The goal of this project is to design a speed model to provide a recommended speed for terrain park jumps that is to be used to build, operate, and maintain a safer park. Successful integration of this model into terrain parks could make jumping more successful, reduce speed related injuries, and create safer terrain parks.

Materials & Methods

To develop a speed model for Terrain Park jumps, the factors that affected a rider's speed needed to be identified. It was found that the jump angles, the distance from the jump to the landing hill, jump height, landing hill angle, landing hill length, and the weather were all factors that affected a rider's speed. Using basic Newtonian Physics equations, dynamics, and the factors listed above a speed model was developed. The field research for this project will be conducted using: a Stabila Electronic Digital Level to measure angles, a Decatur ProSpeed Professional sports radar gun to read skier's and snowboarder's speeds, and a 100-ft. nylon surveying tape to measure jump height and the distance from the jump to the landing hill. The research will begin with field experiments on different terrain park jumps by measuring the features of jumps and recording rider's speeds. The data collected will then be input, analyzed, and compared to the estimated speeds determined by the speed model. By determining the certain forces on a rider that occur at different points on the landing hill, a safe range for landing will then be determined and thus an average recommended speed provided. 3D graphs will be used to display the jump and the different trajectory paths of various speeds. Charts and tables will also be presented comparing the different factors of jumps, their speeds, and model results.

Results

To be presented at the conference

Conclusions

To be presented at the conference

Safety In Big Jumps: Relationship Between Landing Shape And Impact Energy.

H Böhm*, T Krosshaug, V Senner

Technical University Munich, Faculty of Sports Science, Department Sport Equipment and Materials, Munich, Germany

Author contact: boehm@sp.tum.de

Introduction

Snowboard landings from jumps in terrain parks may involve risk of injury (Wakahara et al 2006). The risk of injuries in landings will likely be reduced if the impact loading is reduced. This can be achieved by designing the landing area profile such that its curvature follows the flight path of the snowboarder. However, finding the optimal landing area curvature may be challenging since parameters such as approach speed and jump inclination will affect the flight trajectory. The purpose of this study was to investigate how these variables will affect landing impact loading, and thereby to suggest guidelines for designing landing area profiles.

Methods

This study contains two parts. In part 1, five snowboarders performed a total of 16 jumps each under different take off angles and in-run velocity. Take off angle was varied by the active push off by the athletes. A 3D body kinematics analysis at the take-off phase was done using 2 high speed cameras. Joint centers were tracked using SIMI Motion (SIMI reality motion systems GMBH, Unterschleißheim) software. The athlete's center of mass was calculated using a model of mass distribution (Yeadon, 1990). The flight path including the landing spot of the snowboarders was recorded with two standard DV cameras in a greater focal volume.

In the second part of the study, we built a computer model of the jump and landing area. In this model, the snowboarder was represented by a point mass. Jumping speed was represented by the take off velocity measured on the snowboarders in part one. Using Newton's laws of motion, the flight trajectory of the point mass was calculated, as well as the point of impact on the landing surface. The magnitude of the velocity component perpendicular to the landing surface was used to estimate the impact energy during landing. Impact load was calculated for different snow conditions using a generalized Maxwell model. Calculations were performed on three different landing shapes, the first one is the landing surface of the measurements in part one, the second one is closer to the flight path, the third shape is steeper than the two others.

Results

The simulations are ongoing and final results will be presented at the conference.

Conclusions

To be presented at the conference.

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Terrain Park Table Top Trajectory Analysis

Frederick C. Stone, Jr., P.E., President, FCS Engineering & Development, PLLC, Potsdam, NY
Jasper Shealy*, Rochester Institute of Technology, Rochester, NY

Author contact: jeseie@rit.edu

Introduction

Field study measurements were used to document trajectories of recreational skier and snowboarder flight paths on tabletop features in terrain parks. Newtonian laws of projectile motion have been used to predict landing spots, or the speed at which a jumper left the lip of the takeoff ramp. Typically jumpers are treated as inert objects; disregarding the dynamic effects that a jumper may contribute at takeoff.

Materials/Methods

Fifty-seven jumps were observed. The feature takeoff ramp inclination was 33°, the lip was one foot above the deck, the deck was 30 feet long, the landing slope inclination was 26°. Takeoff velocities were measured using a radar gun and corrected for cosine angles. Flight trajectories were digitally recorded on video and still photographs using an orthogonal location; landing points were noted. Digital image analysis created composite images of the trajectories. Simulated trajectories using Newtonian laws of motion were superimposed to see if equations for projectile motion can accurately predict real-world conditions. A test subject did ten 'neutral' jumps. He was instructed to interact as little possible with the feature at the time of takeoff to establish a baseline for computer simulation comparison.

Results

Thirteen of the 57 observations generally coincided with Newtonian laws for projectile motion (range, height, landing spot, and time of flight). Ten of these observations were by the control subject. The remaining 44 observations included three flight trajectories below that predicted by Newtonian physics and 41 flight trajectories that exceeded predictions. Jumper actions prior to takeoff increase or decrease the "effective" takeoff angle of the trajectory by altering the path of the center of mass of the jumper on the takeoff ramp. Jumpers entering the ramp with a knees bent posture and extending their legs as they transit the ramp, exceed their theoretical range, altitude, and time of flight. Their effective takeoff angles ranged from approximately 40° to 48° (7° to 15° increase in the trajectory takeoff angle). Conversely, the opposite effect occurred if the jumper entered the ramp with legs extended and progressively bent their knees as they ascended the ramp; lower amplitude, shorter range, and shorter time of flight. In this situation, the effective takeoff angle ranged from approximately 22° to 0° (11° to 33° decrease). A neutral posture results in theoretical and actual trajectory agreement.

Conclusions

Newtonian projectile motion laws cannot accurately predict the location where a jumper will land based on just the speed at the point of takeoff and the geometry of the feature. Alternatively, the speed of the jumper at takeoff cannot be predicted based on the feature's geometry and landing location. Jumper actions prior to takeoff dramatically alter the characteristics of the flight. Knowledge of the jumper's activity on the takeoff ramp is essential to understanding the effective takeoff angle, landing point, and the ultimate flight trajectory of the jumper. The study documents the dynamic effect a jumper has on the flight path.

Terrain Park Table Top Landing Impact Analysis

Jasper Shealy*,Rochester Institute of Technology, Rochester, NY
Fred Stone, Engineer, US Army, Watertown, NY

Author contact: jeseie@rit.edu

Introduction

There is a paucity of information as to what the impact loads at various points on the body might be for jumpers using medium sized tabletop features in terrain parks. This study determined what the landing loads at the boot, the chest and helmet were for a jumper doing nominal jumps off a tabletop feature and landing under control on his feet.

Materials/Methods

A jumper/subject (an experienced jumper, age 20, height 5' 10", weight 170 pounds) was instrumented with three Landsmont Tri-axial accelerometers. One accelerometer was fixed to the subject's boot; one to a chest plate firmly strapped to the subject's chest and one was attached to the subject's helmet. The subject performed jumps on two different features. Both features were similar in size, one with a deck length of 20 to 25 feet in length; the other was from 30 to 35 feet in length. Both had take off ramp angles of between 25° and 30°. Accelerations in all three axes on all three accelerometers were measured in real time. The x, y, and z components were resolved into a single vector.

Results

A total of 21 instrumented jumps were recorded. Ten were recorded on the larger of the two features; eleven were recorded on the smaller feature. On the larger feature, the boot accelerometer averaged 75.6 G (SD=14.1), the chest accelerometer averaged 3.7 G (SD=1.6), and the helmet accelerometer averaged 2.5 G (SD=1.1). For the smaller feature, the boot accelerometer averaged 55.7 G (SD=26.3), the chest accelerometer averaged 1.8G (SD=1.8), and the helmet accelerometer averaged 2.1 G (SD=1.3).

Conclusions

As a point of reference, a study of human tolerance for impact to the head obtained from volunteer boxers found that five subjects tolerated without adverse effect G loads to the head ranging from 23 to 143 Gs, and HIC values ranging from 8.6 to 348. In that study, a total of 46 blows to the head were analyzed. In our study, the highest recorded helmet acceleration was 5.7 G. The legs and torso of the subject reduced the average boot sensed impact of 75.6 G to only 2.5 G at the helmet, a 96.7% attenuation in transmitted G loads from boot to helmet.

Trail and Barrier Design Considerations for Ski Racing

Christopher A. Brown
Mechanical Engineering Department, Worcester Polytechnic Institute,
Massachusetts, USA

Author contact: Email: brown@wpi.edu

Abstract

The objective of the work is to advance the understanding of trail design and barrier designs for alpine ski racing and training. Barriers in this work refer to fences and anything else that might be used to mitigate impact or redirect skiers after a fall. This paper reviews the current knowledge and use of barriers and trail design in ski racing and looks for gaps in usage and understanding, in order to propose research and products to fill those gaps. The FIS currently homologates trails for various races, and national organizations train and assign race officials to review safety at events. Trail and barrier conditions at practices are generally under the control of the coaches. However, serious injuries including paralysis and death still occur due to collisions with fixed objects, collisions that could be prevented with improved use of barriers and better trail design. In recent years, fencing has become more standardized and more fully employed; however gaps in understanding and application remain. The current best practice is to use type A fencing in the most dangerous places. This fencing uses a goose-neck arrangement of supports to fix the fence away from its supports, such that the supports cannot be impacted by the racers. These supports are permanent and use cables, placed well above any probable impact location, to support the upper edge of the fence. The lower edge of the fence is fixed to the ground. The tension and elasticity of the fence are controllable and are adjustable so as not to cause injury. Type B fencing is used frequently and is supported on plastic poles that are stuck in the snow, and protection depends on how the poles are retained in the snow. Frequently, three layers of B fencing are used in GS and speed events to slow racers gradually. The method of this research as applied to barriers is to look at how the energy in a fall is dissipated, with specific attention to the negative accelerations that the skier experiences. The placement of barriers is another issue that needs to be considered in studying trail design, given that trail design includes attention to speeds and distances to fixed objects. Additional elements to be examined in the work are grooming practices and burms, or banks at the edge of a trail. The conclusion is that the improvements can be made in barrier and trail design in order to reduce the risk of injury to ski racers.

Improved Pole and Panel Design for Ski Racing

Christopher A. Brown
Mechanical Engineering Department, Worcester Polytechnic Institute,
Massachusetts, USA

Author contact: Email: brown@wpi.edu

Abstract

This paper examines the current design of panels used in ski racing and proposes new ones. The panels in ski racing serve to appropriately mark the course in such a way that it is clearly visible to racers, officials, and spectators. The panels are placed between two poles as defined by the FIS rules. Racers ski close to these poles, often making hard contact with them and sometimes becoming entangled with them. This entanglement can lead to serious injuries, including paralysis and, for males, ruptured testicles. The panels also contribute to minor bruising to the racers in impacts with the poles.. The objective of this paper is to propose designs for panels that satisfy two upper level functional requirements: appropriately marking the course and reducing the risk of injuries to racers. Some candidate solutions, which would have the panel slip off the top of the pole, appear attractive, until the deformation of the pole is considered. During an impact, the pole can bend enough so that the panel cannot slip off immediately, and injurious loads can then be transmitted to the skier. Another issue to consider is how the non-impacted pole reacts to impact, which is influenced by the elasticity of the panel and the height at which it is placed below the top of the pole. Other design requirements include facility for rapid repair of panels between racers and resistance to detachment by the wind, as well as limiting the force bending the poles due to the wind. Design solutions include a detachable mechanism, with force selection determined by the size of the racers, and increased elasticity in the panel, which limits the force on the racer and the non-impacted pole. Current pole design and performance are also examined. The amount of energy transferred to a slalom pole on impact with a racer is estimated as a function of speed and the inertia of the pole. Pole designs with decreased mass are considered. In addition, the paper considers the problem of broken poles with composite poles. One conclusion is that there is the potential to design panels and poles that present less risk of injury to ski racers.

Ease Of Unloading From An Eight Seat Chairlift At Perisher Valley, Australia

Karyn Whelan* Lecturer, School of Physiotherapy, The University of Sydney, Australia
Lucas Coates. Physiotherapist, Sydney, Australia

Author contact: K.Whelan@usyd.edu.au

Introduction

The introduction of eight seat chairlifts has raised the concern of increased risk of collision, falling, and possibly injury while unloading due to the greater number of passengers. This study aimed to investigate: if seat position on an eight-seat chairlift in Perisher Valley, Australia affected ease of unloading; if there was a difference in the fall rate between skiers and snowboarders; and if the time of day or day of the weekend affected ease of unloading.

Methods

Video was used to record passengers' seat position, equipment (skis or snowboard), and ease of unloading (fall or did not fall) from the chairlift during a total of three one hour sessions over two days of a weekend. Seats were numbered from left to right when facing the chairs. Data were analysed using descriptive statistics and the Chi Square statistic ($\chi 2$) ($p=0.05$).

Results

1,103 chairs were observed carrying 7,293 passengers, of which 4,551 (62%) were skiers and 2,742 (38%) were snowboarders. 877 (12%) passengers fell while unloading from the chairlift, with a significant difference between skier falls 133 (15%) and snowboarder falls 744 (85%)($p= 0.0005$). Ski patrol was not required to attend any injuries. There was a significant relationship between seat position and the ease of unloading ($p=0.02$). Seat positions three & four had fewer falls than expected and seat positions seven & eight had more falls than expected. However, for skiers and snowboarders individually, there was no significant relationship found between seat position and ease of unloading. Seats three and four had the lowest number of snowboarders and a high number of skiers, while seats seven and eight had the most equal distributions of skiers and snowboarders and high numbers of snowboarders. There was a significant association between time of day/day of the weekend and ease of unloading ($p = 0.001$) with more falls than expected during the Saturday morning and afternoon sessions, and less falls than expected during the Sunday midday session.

Conclusions

The significant difference between skier and snowboarder falls demonstrates that it was more difficult to unload from the chairlift on a snowboard. From analysis of the seat position variation between the two groups along with the higher snowboarder fall rate, it was concluded that equipment, rather than seat position, had the greatest effect on ease of unloading. The significant association between time of day/day of the weekend and ease of unloading may suggest that practice over a single weekend is sufficient to develop the skills necessary to unload without falling. The high fall rate, particularly of snowboarders, is of concern due to the potential for injury.

Globaltrail: Marked Snowshoe Trails In Switzerland

Monique Walter, Swiss Council for Accident Prevention bfu

Author contact: m.walter@bfu.ch

Introduction

Snowshoe trekking has grown into a trend sport. It is healthy with a low injury risk. It gives non-skiers the opportunity to reach areas that were previously inaccessible to them in winter. This means that they may enter terrain where avalanche danger exists. In comparison to summer hiking, orientation is more difficult and in fog the situation can rapidly become critical. Avalanche knowledge is therefore essential for all snowshoe tours made off the marked routes.

Many snowshoers lack this basic knowledge but nevertheless want to be able trek safely and independently. The increase in emergencies related to snowshoe trekking shows that action is needed. bfu statistics on sport-related fatalities already include eight deaths from snowshoe-trekking accidents during the three winter periods 2003/04 to 2005/06. Mountain rescue teams record an increase in the number of missions dealing with snowshoers. Hence bfu is engaged on making sure that, as far as possible, no serious injuries or fatalities occur on snowshoe treks. First and foremost, it is to be made possible for the large number of beginners to take risk-free "tester" treks.

Materials/Methods

Globaltrail experts and the bfu have together developed a system of marking snowshoe trails and issued an information brochure in three languages, giving tips from planning and equipment to avalanche dangers. It is available from trail operators and snowshoe rental operators.

The trails are marked as blue, red or black by the operators, depending upon the degree of difficulty. Blue denotes an easy route, particularly suitable for beginners. Trails are made safe by the operators but remain basically unprepared. Trails with acute avalanche danger are closed. Trails are used entirely at the snowshoer's own risk. Globaltrail provides the standard marking panels and offers an information platform. All routes with operators, maps and further information are available at www.globaltrail.net.

Results

According to feedback from operators, the trails are very popular with snowshoers. About 20,000 information brochures were handed out in the first two winters. In the meantime, the number of trails has grown to almost 100 in over 30 Swiss winter sports regions. Unfortunately no up-to-date detailed information is yet available on snowshoeing accidents.

Conclusions

The markings and safety measures on snowshoe trails in Switzerland offer those interested in this healthy sport the chance to get their first feel of snowshoe trekking in relative safety, even with little experience or training. Let's hope that this results in a drop in the number of serious injuries and fatalities!

Social Factors in Australian Snowsport Injuries

Tracey J Dickson, PhD*. Centre for Tourism Research, University of Canberra, Australia, 2601
Jeni Saunders, MD. Sports Physician, Nuggets Crossing Family Practice, Jindabyne, Australia, 2627

Author contact: Tracey.Dickson@canberra.edu.au

Introduction

This research sought to investigate the social factors that may contribute to snowsports injuries such as fatigue, hydration, drugs, alcohol and protective equipment use.

Methods

All individuals injured on-snow during 31 consecutive days in winter 2006, 18 years or over, and who presented to one of four medical practices in the Snowy Mountains area of Australia were invited to complete a 2-page self-completion anonymous questionnaire. Accidents while crossing the car park were excluded as were patients with serious conditions precluding their ability to complete the questionnaire. Those with hand or wrist injuries were provided with a scribe if necessary.

Results

Preliminary descriptive results

- 497 completed questionnaires (45.02% female and 54.98% males), age range: 18-83 years ($\bar{x}$ =33.36 years, mode=21 years)
- Activity at time of injury: alpine skiing (49.3%), snowboarding (46.1)%, cross-country skiing (1.0%), telemarking (0.6%), snowplay and/or snowball fights (0.6%) and tobogganing (0.4%)
- Of the injured respondents:
    - 22.1% first commence skiing/boarding in 2006
    - 20.4% had had no snowsport lessons
    - 27.8% had 6 days or less experience
- 47.5% of injures occurred on-piste
- 38.2% of injuries were a result of falling over
- Injury type (as indicated by respondent): sprains (65%), fracture (23.2%), bruising (12.2%) dislocations (8.2%) lacerations (5.1%). Snowboarders reported 63.7% of all fractures, (n=65, 28.4%), 2.1 times the rate for alpine skiers (n=33, 13.5%)

Top 3 injury locations
Knee (23.9%) Shoulder (14.7%) Wrists (13.1%). Of 40 reported fractures, 35 (87.5%) were snowboarders, (53.8% of all reported fractures)

Other Factors

Glasses/contact lens - 32% of respondents required glasses/contacts for long distance. 45.2% were not wearing them at the time of injury (i.e. 14.5% of all injuries). In the 24 hours prior to the injury: Fatigue - 32.6% reported sleeping less than normal, 43.4% reported poor to fair sleep. Those with less than 14 days experience reported the biggest sleep deficit. Hydration – difference from normal: 36% drank more alcohol (59.8% alpine skiers, 37.6% snowboarders), 17% drank less 'other' drinks. Drug use: Marijuana (2.6%), speed (0.4%), ecstasy (0.4%), cocaine (0.2%)

Conclusions

There are other social factors that may be contributing to the rate and severity of snowsport injuries (e.g. fatigue and hydration) that could be effectively managed through effective safety messages that integrate with existing snowsport safety strategies.

Snow Risk, Snow Fun: Personal Responsibility in an "Extreme Sport"

Dr Tim Squires, Division of Pathology (Forensic Medicine), The University of Edinburgh

Author contact: t.squires@ed.ac.uk

Snowsports are exciting – I think we can all agree on that! But as with any mountain activity, the excitement is accompanied by an element of risk.

> But what do we mean by "risk"?
> What is an "acceptable" risk?
> And, crucially, can we promote the concept of personal responsibility as the route to balance competing interests such as insurance, negligence litigation and mechanical safety with our freedom to enjoy our sport?

This presentation examines the role of individual participants' responsibility for reducing risk and keeping snowsport "safe". Comparisons will be made with sports such as climbing and sailing and draws on the literature relating to utilitarian activities such as driving, home safety and safety at work legislation and litigation.

The term "Extreme Sport" is a relatively recent addition to our vocabulary and one which encapsulates a desire to escape our increasingly regulated and protected society. But the term can be misleading and is often used as a demographic description of its participants rather than being a measure of risk. Furthermore, in some so-called extreme sports (and in the absence of negligence or faulty equipment) there is a significant gulf between the actual risk and the perceived risk (bungee-jumping is marketed as an extreme sport but is essentially zero-risk as the participant has no input into the outcome – it is even possible to buy computer games which "create an extreme sport experience" (sic)).

In a genuine extreme sport, the participant is surely required to use their skills, training, judgement and experience to assess and control the risks. Indeed, that control is what makes the activity a sport and a valuable human endeavour and not just dangerous behaviour (or stupidity) – the forensic literature contains many references to the latter!

Sport *should* be challenging; it *should* offer the opportunity to "live on the edge", to "test one's own limits" (irrespective of where these might be) or, more simply, to "take a risk". The epitome of this is seen in competitive sport – but we note the recent call in the BMJ to remove contested scrums from the game of rugby union because of a risk of spinal injury. Over-regulation will sanitize the sport and render it devoid of the essential qualities which motivated men to take to the slopes for pleasure many years ago. It must be education not regulation: there is a need to educate participants that they do have responsibility for keeping the slopes safe – a small price to pay for the freedom of the mountains.

The presentation examines these issues and suggests as a conclusion:

> Those who risk nothing achieve exactly that… nothing.
> Having fun can be risky… taking risks can be fun.

Decision Making Regarding Investment In Injury Prevention Utilising A Cost Benefit Approach.

Kylie Holmes* and Simon Gianotti – The Accident Compensation Corporation (ACC), Wellington, New Zealand

Author contact: kylie.holmes@acc.co.nz

Introduction

The Accident Compensation Corporation (ACC) is the New Zealand crown entity charged with the administration of New Zealand's no fault accident compensation scheme. A person can make a claim to ACC for payment of medical treatment and rehabilitation costs associated with injury. In an attempt to minimise claim costs, ACC invests in a number of injury prevention programmes. To assist with decisions regarding investment in national sports injury prevention programmes, ACC utilises the break even point (BE) formula and behaviour change rate (BCR) formula. This paper outlines the application of these formulae with regards to the implementation and investment in a national snow sports injury prevention programme within New Zealand.

Materials/Methods

ACC has a claims database which enables the average lifetime cost (ALC) of a new claim to ACC to be estimated. The ALC is used in the BE formula. The BE formula determines the number of entitlement claims (ECs) that an injury prevention programme must prevent to break even. ECs are moderate to serious injuries requiring entitlement beyond medical treatment only and represent 85% of sport claim costs to ACC. They are therefore the primary focus of injury prevention. BE = PC/ALC where PC = direct programme costs excluding overheads. The BE point is then used to determine the required BCR. BCR% = BE/(T*(H/M)) where T = number of people that the injury prevention programme will target, H = number of historical ECs yearly in that sport and M = maximum yearly number of snow sport participants.

Results

An examination of 7,276 snow sport ECs between 1995 and 2006, estimated the ALC of a snow sports EC to be $NZ8,083. The planned investment for the snow sports budget for the 2006/07 financial year was $NZ120,000. Using the BE formula, for 2006/07 the programme must prevent 15 new entitlement claims to break even. M_{06} = 300,000, T_{06} = 234,000 and H = 944. This equates to a required BCR of 2.0% to give a ratio of $NZ1 saved for every $NZ1 invested. Comparison of this figure against previous experience and existing evidence indicates that this is an achievable target and subsequently a justifiable level of expenditure.

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Conclusions

The BE point and BCR can be used to determine the financial benefit of investing in a snow sports injury prevention programme. In addition, they enable a desired behaviour change rate among snow sport participants to be determined pre-implementation. This results in an improved decision making process regarding review and continuing investment in a snow sports injury prevention programme.

The Effect of Visibility on Chosen Speed of Skiers and Snowboarders

Erin Harley[1], David Krauss[1], and Irving Scher*[1,2]

Author contact: ischer@exponent.com

[1]Exponent Failure Analysis Associates, Los Angeles, CA, USA
[2]Department of Biokinesiology and Physical Therapy, University of Southern California, Los Angeles, CA, USA

Fog, cloud cover, and shade on a ski slope reduce contrast of features in the visual environment. Reduced stimulus contrast impairs visual perception by reducing the rate at which an observer can acquire information from the environment (Harley *et al*., 2004), and by biasing motion perception—when the contrast of a moving stimulus is decreased, perceived motion is slower than veridical motion (Thompson, 1982). The latter effect has been shown to have real-world applications, e.g., drivers will increase their speed under foggy conditions because they perceive that the car is moving more slowly than is actually the case (Snowden *et al.*, 1998). It remains unknown whether or not people adjust their speed inappropriately in other venues (e.g., skiing and snowboarding) when visibility is poor. In the present study we investigated the relationship between visibility and chosen speed of skiers and snowboarders. When skiers and snowboarders are required to monitor their speeds on the slopes (e.g., when approaching a 'Slow' sign), common sense dictates that they will choose a slower speed when visibility is reduced in an effort to remain cautious; however, biased motion perception during poor visibility conditions may lead them to choose a counterintuitive, faster speed compared to clear conditions. Under different visibility conditions, we measured the speeds of approximately 1000 skiers and snowboarders as they approached 'Slow' signs on beginner and intermediate slopes at Mammoth Mountain, California. Preliminary analyses suggest that skiers and snowboards travel at slightly faster speeds when visibility conditions are poor. Though surprising, this result is consistent with the findings described in the literature on motor vehicle driving (Snowden *et al.*, 1998). Full results will be presented at the conference.

An Exploratory Study Into Risk-Taking And Injuries Among Interschools Alpine Racing Teams.

Ms Nadine Cooper*, University of Canberra. Australia

Author contact: nadine.cooper@student.canberra.edu.au

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Introduction

Risk taking and sensations seeking are common daily phenomena that every person experiences to some degree. Sensation seeking behaviors have been found to be common among those engaging in activities such as mountaineering, deep sea diving, skiing and snowboarding, all of which may be considered relatively high-risk activities for accidental injury. Risk-taking behavioural characteristics have been identified as a possible explanation for the higher incidences of snowsport injuries. These snowsports attract a proportion of the population including many children, who have been introduced to the sport through school sponsored ski programs and local community clubs. The number of children and adolescents participating in snow sports continue to rise and therefore it is important to have snow safe programs implemented within ski resorts and in place in schools participating in alpine sports programs. In Australia, NSW and ACT Interschool Snowsports entries since 2001 have increased by 204 %, from 465 entries in 2001 to 1485 entries in 2006. Therefore the occurrence of alpine injuries may have increased substantially, which is not only a problem for the participating groups, but also represents a potential public health issue.

Materials / Methods

An exploratory questionnaire based study of Southern NSW and ACT Interschools Alpine Racing Teams was conducted during the 2006 winter season. The purpose was to investigate injury trends, sensation seeking and risk-taking in an adolescent population. The aim of the study was to analyse and evaluate the effects of the combined psychological characteristics of risk-taking and sensation seeking on injuries sustained. A second purpose was to quantify protective equipment habit and attitudes towards it with participants in secondary school. The rationale behind the study incorporated the benefits of knowing higher risk-taking groups and how they relate to injury. The results can be implicated and used to design and employ more appropriate Interschools training, risk management and injury prevention programs.

Results

Sixty-six participants undertook the questionnaire and the participant's ages ranged from 12-18 years old with the mean age of 14 years. Alpine skiing accounted for 68.2% of the participants, snowboarding 21.2% and 10.6% cross-country. Of the 66 participants 33 suffered injuries prior to the 2006 winter season, with 19 participants having sustained two or more injuries and one participant was injured 10 times. There was a total of 72 injuries amongst the 66 participants.

Of those injured, 62% were injured while free skiing or snowboarding, 28% during training and 10% while racing. The majority (74%) of injuries were sustained while skiing with friends, 13% skiing with family and 13% skiing alone. From these results there appears to be no direct correlation between risk-taking behavior and injury.

Conclusion

The majority of accidents are while children are skiing with friends and not racing.

Behaviours And Attitudes Towards Snowsport Safety: Australia 2006

Tracey J Dickson, PhD*
Research Fellow
Centre for Tourism Research
University of Canberra, ACT, Australia

Author contact: Tracey.Dickson@canberra.edu.au

Introduction

On line survey based upon previous research was posted for a 3-week period to explore: protective equipment use, risk taking behaviours, and perceptions of risks in snowsports.

Methods

The on-line survey was posted on an Australian website, www.ski.com.au, for 3 weeks during winter 2006 which invited anonymous participation from visitors to the web-site. The questionnaire was based upon Langran, M. (2004) *Snowboard Attitudes Study,* available at http://www.ski-injury.com/sas.htm.

Results

There was little difference in helmet wearing between males (37% wear them often or always) and females (36%), but there is a large difference in helmet wearing across skill levels: beginners (20%), intermediates (21%), advanced (49%) and expert (33%). Snowboarders are most likely to wear a helmet (45%) compared to 35% of alpine skiers. The four main reasons for not wearing a helmet from 6 items were: *Don't see the need* (45%), *Uncomfortable to wear* (24%), *Too expensive* (15%), and *Don't like the look* (15%)

Only 33% of all snowboarders (n=17) wore wrist guards. The three main reasons for not using wrist guards were *Don't see the need* (54%) *Uncomfortable to wear* (42%), and *Don't believe they'll protect against injury* (21%). Given a choice snowboarders preferred wrist guards inside gloves (82%) than outside gloves (18%).

From 7 items, the most risky activity was considered to be *Being out of control*, followed by *Going fast in ungroomed areas* and then *Performing jumps*. *Using a tow or lift* was seen as least risky.

When skiing/boarding intentional risks were taken *Sometimes, Often* or *Always* by 45% (alpine skiers=44%; snowboarders=50%) and unintentionally by 24% (alpine skiers=24%; snowboarders=23%).

Respondents believed injury rates were higher than international statistics (approx 3/1,000 skier days), with 26% estimating more than 20 injuries per 1,000 skier days; 15% estimated 16-20; 13% estimated 11-15 and 26% estimated 6-10 injuries. Only 18% estimated 1-5 injuries per 1,000 skier days.

Conclusions

More experience participants are likely to wear helmets than beginners or intermediate participants. Snowboarders are most likely to wear helmets, but have a low level of wrist guard use. The main reason for not wearing either a helmet or wrist guard is that there is no perceived need.

- The most risky activities were considered to be *Being out of control* and *Going fast on ungroomed areas*.
- More snowboarders intentionally took risks on snow than alpine skiers.
- Participants, even though experienced, overestimated the risk of injury in snowsports.

Evaluation About A Group Of Young Skiers For Training Program Planning And Injuries Prevention.

Fulvio Stradijot* - Rehab centre Area 3; Cantalupa (To), Italy

Author contact: fulviostradijot@areatre.net

Introduction

The purpose of the work is the analysis of data collected with 3 test (isokinetic, proprioceptive and jump test) in relationship of training program planning and injuries prevention for next season, upon a group of competitive young skiers.

Methods

There were processed results of 30 athletes (17 males and 13 females) mean age 16.6, 22 with right dominance and 8 with left dominance, all involved in ski team activities. The young skiers have been evaluated with an isokinetic device (Biodex System 3) at 3 speeds (240 °/sec, 120°/sec and 60°/sec.) to compare the different values of knee extensors and flexors strength , with an electronic balance board (Delos) about the proprioceptive ability and with an optic fibre device (Optojump) for the assessment of strength in vertical loading , with 1 and 2 legs.

This work processed only the side to side data collected in the different trials.
Results were divided in 3 groups:

1) Total group,
2) Healthy group
3) Group with recent injuries (last 6 months).

In the first 2 groups were analyzed the general differences (isokinetic strength of knee extensors and flexors, proprioceptive ability and strength in vertical jump) between the 2 legs as well as the same kind of difference in relationship to the dominant side; in the third group the above mentioned differences between the involved and uninvolved side.

Results

In all test, healthy athletes present a balanced situation under all the points of view between the 2 limbs, while people with recent injuries, showed positive or negative differences between the 2 sides: an heritage of their recent history of traumas and rehabilitation.

Conclusions

In all 3 test we can see a general side to side balance in healthy athletes, meanwhile people with recent injuries show differences more or less important, probably due to an inadequate rehabilitation and a lack of objective functional evaluation. In rehabilitation as well as in training planning, functional evaluation of the people is very important. Everybody can use available devices, but is basic consider even an objective point of view.

Immobilisation In External Rotation After First Shoulder Dislocation. International Prospective Study:

MH Binet, JM Bertrand, Avoriaz, France
Liavaag Sigurd, Norway
Geneviève Tessier, Sherbrooke, Canada

Author contact: binet@mdem.org

The rate of recurrence of shoulder dislocation after a first episode for young subjects remains important and alarming. Since the last publications of the Japanese ITOI, the question is:

"Does an immobilisation with the arm in external rotation reduce the occurrence of re-dislocation?"

A Norwegian team tries to show this assumption thanks to a great multicentric study. A few French doctors of the epidemiologic group "Medecins de Montagne" joined this study and started to propose the immobilisation in external rotation for half of patients victims of a primitive dislocation of the shoulder.

Two groups of patients are separated in the study, a younger group between 16 to 24 years and a second group for patient between 25 to 39.

Patients over 40 years old are excluded of the study.

The other exclusion criteria for this study are:

- fracture of the glenoïd with defect of more than 20% of the surface
- great tuberosity fracture with a space of more than 1 cm between the two pieces after reduction.
- nerve damage following dislocation or relocation

The follow-up is made through questionnaires sent after 3 weeks, one year, two years and four years. The questionnaires are initially treated in French because of the linguistic barrier, then the results are transmitted to the Norwegian team for integration in the international data base.

We hope to be able to give the first results on the follow-up during the congress of Aviemore in May 2007.

Osteoarthritis Of Lower Extremities In Former Skiers

M. Iosifidis*, A. Tsarouhas, D. Kotzamitelos, E. Georgopoulos, G. Giantsis
Orthopaedic Department, Naoussa G.H., Greece

Author contact: iosfyl@med.auth.gr

Introduction

Elite athletes' sports activities cause increased loads in their joints. In vitro articular cartilage is destroyed under 25 MPa. The aim of our study was to investigate the prevalence of lower extremities osteoarthritis in former elite skiers.

Methods

We studied the functional condition and recorded the radiological image of lower extremities joints in 42 former male skiers with a mean age of 53.5 years (SD + 11.31) who participated in national championships and in international games with the national team. The control group was 181 males (mean age 50.67 SD + 10.04) who didn't have systematic sport activity and who were completely healthy when they had their military obligation. The participants in the study did not have diagnosed and/or operated lower extremities musculoskeletal injury. Osteoarthritis was evaluated through a questionnaire, clinical examination and radiological evaluation.

Results

After adjusting the age, height, weight and body mass index (BMI), we made statistical analysis (student's t-test, z-test $p<0.05$), and recorded an increase of prevalence of hip osteoarthritis in former skiers compared with a control population (9.52% and 3.31%, respectively, $p<0.01$). Interestingly, the x-rays of the former athletes showed increased arthritic signs without as dramatic clinical manifestations of knee or ankle osteoarthritis as the radiographs suggest for these joints.

Conclusions

There are many studies in the literature about the question if sport activity, especially high level, is a predisposition factor for osteoarthritis. Analyzing our results we could assume that the increased prevalence of lower limb OA in former skiers might be caused from their professional sport activity.

Histological And Electron Micrographic Evaluation After ACL Reconstruction With Bone-Patellar Tendon-Bone

Tsuneo Yamagishi*, Keishi Marumo, Chiaki Yoshimatu, Hidehiko Suzuki, Miki Ozawa and Hiroya Okutsu

Department of Orthopaedic Surgery, Jikei University School of Medicine,Tokyo Japan

Author contact: tsuneo-y@gd5.so-net.ne.jp

Introduction

The purpose of this study was evaluated collagen ultrastructure in reconstructed ACL with bone-patellar tendon-bone autograft.

Materials

Four hundred ninety-two cases included 234 men and 258 women out of 1028 ACL reconstruction using bone-patellae tendon-bone autograft underwent second-look evaluation for histological and electron micrographs. The age at the time of second procedures were range from 14 to 60 years, the average age was 28.8 years. 492 cases (234 men, 258 women) performed biopsy under arthroscopic visualization for histological analysis.

Methods

All the patients were operated by a single surgeon with two incision technique. Clinical evaluation was assessed by the IKDC form. Anterior displacement was measured with KT-2000 arthrometer at 30 lb. These patients also were performed magnetic resonance imaging at 6, 12, more than 24 months postoperatively. Second-look evaluations assessed with modified Kohn's criteria and performed biopsy for histological analysis with H & E, Safranin –O methods and electron micrographs.

Results

Outcomes of the second-look evaluation 62 % were Excellent, 28 % Good, 8 % Fair, 2 % Poor. The statistically difference was seen between Excellent and Good in side to side difference measured with A-P translation. MRI evaluation revealed that Excellent was 55 %, Good 35 % and Poor 10%. IKDC scores was 77 % Normal, 17 % Nearly Normal, 4 % Abnormal, and 2 % Severely Abnormal. The ACL graft had a collagen fiber orientation in which longitudinal collagen bundles demonstrated a coarser amplitude crimp pattern. Electron micrographs demonstrated a uniform small-diameter collagen fibrils profile after 1year postoperatively while small- and large-diameter fibrils after 3 years postoperatively.

Conclusion

This study demonstrates that the return to normal of the collagen fibrils in reconstructed ACL have to need long period for the mechanical properties of ligament healing

Randomized Physiological Tracer Tests of Equipment and Interventions without Additional Radiation Burden in Patients undergoing Routine Nuclear Medicine (Cardiac Stress) Tests.

Fredrick G. Hoeflin MD*[1], Paul Dubach MD[2]
[1]Dept of Nuclear Medicine, [2]Dept of Cardiology, Kantons Hospital Graubuenden, Chur, Switzerland.

Author contact: frieder.hoeflin@ksgr.ch

Introduction

Most skiers have a personal experience of perfusion problems in thightly fitting ski boots. In professional skiers at the end of the season chronic feet problem are frequent. Every year more than 2 million patients in the US alone undergo Myocardial Perfusion Tests by Nuclear Medicine Procedures. These tests for predictions of coronary stenoses have a high sensitivity and an excellent safety profile. Measurements of peripheral perfusion are possible in patients undergoing routine tests of Myocardial (= central) perfusion without affecting injection technique, imaging and quality of the routine investigation. The tracer substances used accumulate according to the local perfusion in mitochondriae (of cardiac and other muscle) within minutes after injection, stay there for hours and can be visualized and quantified within the halflife of the tracer. No additional tracer application is needed and there is no additional radiation burden. We have done a pilot study to show the feasibility of this approach.

Patients

3 male patients 28, 62 and 67 years old. No history of peripheral perfusion problems. No myocardial perfusion deficits at cardiac study.

Material and Methods

Sestamibi ® tagged with 740 MBq of Tc99m (T ½ =6h) is injected in the patient wearing only one ski boot (randomized left or right). Minutes after injection the boot is removed and the routine myocardial test is done by Single Photon Emission Computed Tomography (SPECT), later perfusion in both legs is visualized and quantitated by planar scintigraphy with symmetrical regions of interest.

Results

Count rate differences in % (boot /no boot) respectively are 6.5/93.5; 23.8/76.2; 12.8/87.2.

Conclusions

The results show the feasibility of this technique. A high number of patients can be enrolled with informed consent. Interventions as the application of heat or cold in extremities can also be tested. In our limited pilot study on ski boots the results are striking. However more randomized studies should be done.

Practising Nuclear Medicine (NM) in a Winter Sport Region with an Open Mind on Aspects of Skiing Safety.

* Fredrick Hoeflin, MD, Dept of Nuclear Medicine, Kantons-Hospital Graubuenden, Switzerland.

Author contact: frieder.hoeflin@ksgr.ch

Introduction

In winter sport most musculo-skeletal problems are acute and the diagnostic workup is done by conventional X-Ray, CT or MRI. Chronic injuries as stress reactions on various skeletal locations and the interface of bone and tendons are best investigated by the NM Three Phase Bone Scan. Lesions of the first Metacarpal Region (Thumb) can easily be detected in Routine NM Whole Body Bone Scans. The problem of perfusion in footgear is different in Skiers (most using hard boots) and in Snowboarders. Perfusion in the extremities specially in the legs can be investigated and measured by different NM techniques (see seperate abstract). Pulmonary embolism caused by thrombi originating at the site of local compression by ski boots is not so rare (seek and you will find).

Material /Methods and Results

The different NM Methods and their respective results will be presented.

Conclusions

Chronic musculoskeletal injuries are mostly seen in young hard training skiers and boarders. Lesions of the first metacarpal region are not infrequently detected in skiers of all ages. In a retrospective study thumb problems were more a problem in cross country skiers and less so in downhill skiers. A prospective study is under way. Perfusion Problems of the feet in boots can become chronic and often escape detection. Lung Embolism is not infrequent specially in older skiers.

Ski Helmet Design And Functionality: Computer Simulation Using A Validated Head-Neck-Model

Lehner, Stefan*[1], Senner, Veit[2]

[1]Engineering Consultant, Mayerbacherstr. 10, 85737 Ismaning, Germany
[2]Department Sport Equipment and Materials, Technische Universität München, Germany

Author contact: ing.lehner@web.de

Introduction

The issue of sport specific ski helmet design and functionality becomes more and more important. Protection capacity of a ski helmet is a combination of its fitting to the skier's head, the design of the closure system, the tightness of its fixation and above all its impact management. The latter also depends on several factors, i.e. the thickness of the soft padding, its damping property and the elasticity of the helmet's shell.

Even though skier-tree collision is stated as one of the most common reasons for head injuries in skiing and snowboarding little knowledge is available what concerns kinematics and kinetics of this type of accident. This suggests that there is no common mechanism to the occurrence of concessive injuries or skull fractures in these sports. The goal of this study was to simulate head-tree collisions using a validated computerized head-neck model. Various starting and boundary conditions of the impact (i.e. impact energy, trajectory, helmet properties and fitting) should be analysed with respect to the resulting head and neck loading situation due to these impacts.

Material and Methods

Based on CT data a multi body system (MBS) model was developed using exact mathematical descriptions of bone geometries of thoracic and cervical vertebras (T3 to C1) and the cranium. Ligaments, tendons, and cartilage layers were modelled using their individual stress-strain functions. Preceding cadaver tests provided these functions and allowed to validate the mathematical model. Special attention was put on testing the biomechanical behaviour of the intervertebral discs. The used experimental set-up applied torque in the three main anatomical planes (frontal, sagittal, transversal) and evaluated the resulting motion with an optical 3D analysis system.

Neck and head muscles are considered, a total of 25 muscles is modelled as control units. Depending on their physiological cross sectional area and the resulting maximum force hereof each muscle takes a definite load share in the execution of the neck-head-motion to be reproduced. A problem is the classification of head injuries. In this study the Head Impact Power (HIP) Index formulated to quantify risk of concessive injuries in the American National Football League (NFL) depending on the linear and rotational head kinematics was used. In this study a direct skier-tree collision - with and without wearing a ski helmet - was investigated. The elasticity and damping properties, mass and inertia of a modern commercially available ski helmet were used.

Results

Currently we are performing the computer simulations, the results of which will be available for the conference. We expect that the HIP is not significantly reduced by the use of the helmet.