Tibial Fractures in Alpine Skiing and Snowboarding in Finland : A Retrospective Study on Fracture Types and Injury Mechanisms in 363 Patients

Stenroos, A.

2016-09

Stenroos , A , Pakarinen , H , Jalkanen , J , Malkia , T & Handolin , L 2016 , ' Tibial Fractures in Alpine Skiing and Snowboarding in Finland : A Retrospective Study on Fracture Types and Injury Mechanisms in 363 Patients ' , Scandinavian Journal of Surgery , vol. 105 , no. 3 , pp. 191-196 . https://doi.org/10.1177/1457496915607410

http://hdl.handle.net/10138/224644
https://doi.org/10.1177/1457496915607410

publishedVersion

SJS
Scandinavian
Journal of Surgery

Original Article

TIBIAL FRACTURES IN ALPINE SKIING AND SNOWBOARDING IN FINLAND: A RETROSPECTIVE STUDY ON FRACTURE TYPES AND INJURY MECHANISMS IN 363 PATIENTS

A. Stenroos[1], H. Pakarinen[2], J. Jalkanen[3], T. Mälkiä[4], L. Handolin[1]

[1] Department of Orthopedics and Traumatology, Helsinki University and Helsinki University Hospital, Helsinki, Finland
[2] Department of Orthopedics and Traumatology, Oulu University Hospital, Oulu, Finland
[3] Department of Pediatric Surgery, Kuopio University Hospital, Kuopio, Finland
[4] Department of Orthopaedics and Traumatology, Rovaniemi Central Hospital, Rovaniemi, Finland

ABSTRACT

Background and Aim: **Alpine skiing and snowboarding share the hazards of accidents accounting for tibial fractures. The aim of this study was to evaluate the fracture patterns and mechanisms of injury of tibial fractures taking place in downhill skiing and snowboarding.**

Materials and methods: **All patients with tibial fracture due to alpine skiing or snowboarding accident treated in four trauma centers next to the largest ski resorts in Finland were analyzed between 2006 and 2012. The hospital records were retrospectively reviewed for data collection: equipment used (skis or snowboard), age, gender, and mechanism of injury. Fractures were classified according to AO-classification.**

Results: **There were 342 skiing and 30 snowboarding related tibial fractures in 363 patients. Tibial shaft fracture was the most common fracture among skiers (n = 215, 63%), followed by proximal tibial fractures (n = 92, 27%). Snowboarders were most likely to suffer from proximal tibial fracture (13, 43%) or tibial shaft fracture (11, 37%). Snowboarders were also more likely than skiers to suffer complex AO type C fractures (23% vs 9%, $p < 0.05$). Adult skiers had both wider variety of fractures and higher prevalence of proximal tibial fractures compared to children (49% vs 16%, $p < 0.05$). Skiers typically got injured due to falling down on the same level (70%) and snowboarders due to loss of control while jumping (46%).**

Conclusion: **The most important finding was the relatively high number of the tibial plateau fractures among adult skiers. The fracture patterns between snowboarding and skiing were different; the most common fracture type in skiers was spiral tibial shaft**

Correspondence:
Antti Stenroos
Department of Orthopedics and Traumatology
Helsinki University and Helsinki University Hospital
PO Box 266
Helsinki FI-00026 HUS
Finland
Email: antti.stenroos@hus.fi

Scandinavian Journal of Surgery
2016, Vol. 105(3) 191–196

DOI: 10.1177/1457496915607410
sjs.sagepub.com
SAGE

fracture compared to proximal tibial fractures in snowboarders. Children had more simple fractures than adults.

Key words: Skiing; snowboarding; tibial fracture; lower leg fracture; injury mechanism

INTRODUCTION

In Finland, on average one-fifth of the population do downhill sports at least once a year (1). Skiing (Ski) and snowboarding (SB) have a reputation as a risky sport due to frequent knee injuries and lower leg fractures. In general, overall injury rates in skiers have fallen from 5 to 8 injuries per 1000 skier days in the 1970s to 2–3 injuries per 1000 skier days at present; the tibial fractures remain as daily work of hospitals near ski slopes. In the early 1980s, Blitzer et al. (2) reported that tibial fractures were the second most common injury in children, the third most common injury in adolescents, and the eighth most common injury in adults. In previous more recent reports, lower leg fractures made approximately 5% of all injuries in recreational skiers (3–5).

The aim of this study was to characterize alpine skiing and SB-related lower leg fractures in terms of finding specific fracture patterns to these two different sports, and to find out the mechanisms of injuries behind these.

PATIENTS AND METHODS

The study period was of 7 years (1 January 2006 to 31 December 2012) resulting in six full ski seasons (normally from October to May). Patients with tibial fracture (S82.1, S82.2, S82.3) due to alpine skiing or SB accident, excluding tibial malleolar fractures (S82.5 and S82.6), were analyzed retrospectively in three University Hospitals (Helsinki, Kuopio, and Oulu) and in one secondary level center (Rovaniemi). Three of the hospitals were chosen on the basis of their location next to the largest ski resorts in Finland (Kuopio, Oulu, and Rovaniemi). There are only small ski resorts in the Helsinki capital area, but a high number of people originating from there travel to larger ski resorts and in case of an accident, many of them are referred to Helsinki University hospital for treatment.

The hospital records and X-rays were reviewed for data collection as follows: used equipment (skis or snowboard), age (patients younger than 16 years were defined as children), gender, and mechanism of injury (loss of control on the same level, loss of control in jump, collision to another skier, collision with immovable object, or unknown).

Tibial fractures were classified according to AO-classification (6) in terms of finding the fracture patterns in skiers and snowboarders. In AO-classification, the anatomic location of a fracture is designated by two numbers, one for the bone and one for its segment. Each long bone has three segments: the proximal, the diaphyseal, and the distal segment. Proximal and distal fractures are divided into three subgroups (A: extra-articular; B: partial articular; C: complex articular). In diaphysis, the subgroups are A, simple; B, wedge; and C, complex fractures. AO groups and subgroups involve a progressively detailed description of the fracture patterns within these categories. More detailed information on AO-fracture classification in tibia is presented in Fig. 1.

Results are presented as means ± standard deviation (SD) for continuous nonskewed variables. The frequency distribution of the categorical variables is compared between the groups with the Chi-square test. Statistically significant level is set as $p < 0.05$. Statistical program SPSS (IBM Corp. released 2009. IBM SPSS Statistics for Windows, version 13.0. Armonk, NY: IBM Corp.) was used for analyses.

The study protocol was approved by Helsinki University hospital's review board.

RESULTS

There were 372 skiing or SB-related tibial fractures (342 in skiers and 30 in snowboarders) in 363 patients. Nine patients had more than one fracture at regio (AO) 41–43. One child on skis suffered 2 tibial fractures on two different occasions on the same tibia. The mean age of the patients was 22 years (range: 3–69 years). More than half of the injured were children. The patient demographics related to used equipment is presented in Table 1. A total of 38 (11%) fractures were open among skiers and 5 (17%) in snowboarders. Adult skiers were more likely to suffer an open fracture than children (17% (n = 25) vs 7% (n = 13), $p < 0.05$). Only one child on snowboard suffered an open fracture.

Tibial shaft fracture (AO 42) was the most common fracture among skiers with 215 fractures, followed by proximal tibial fractures (AO 41) (n = 92) and distal tibial fractures (AO 43) (n = 35). Snowboarders were most likely to suffer either proximal tibial fracture (n = 13) or tibial shaft fracture (n = 11) (Fig. 2) followed by distal tibial fractures (n = 6). In both skiers and snowboarders, the diaphysis was the most common fracture type in children (Fig. 2). The prevalence of proximal tibial fractures was significantly higher in adult skiers than in children (49% (n = 61) vs 16% (n = 31), $p < 0.05$). The prevalence of distal tibial fractures was equal (10% (n = 20) vs 10% (n = 15), $p < 0.05$). SB children did not suffer any distal tibial fractures. There were no significant gender-specific differences in fracture location.

The more detailed fracture classification regarding AO A–C types in both adult and children skiers and snowboarders is presented in Fig 3A (proximal), 3B (diaphyseal), and 3C (distal).

Type B proximal tibial fractures (n = 41) were the most common fracture type among skiers followed by type A (n = 30) and type C (n = 21). Snowboarders were

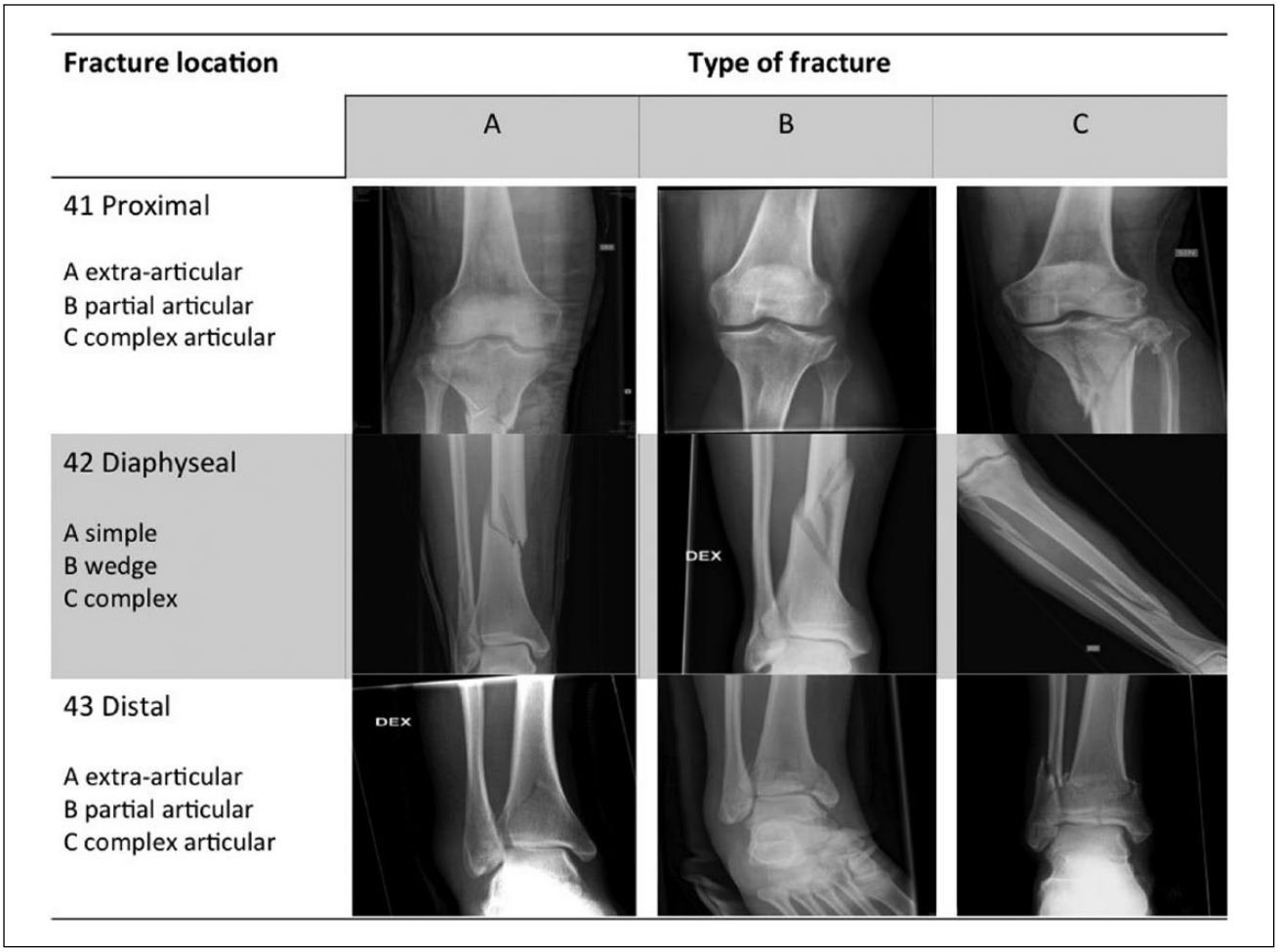

Fig. 1. AO-fracture classification in tibia presented by example plain X-rays observed in study patients.

TABLE 1
Demographics (SB = snowboard).

	Ski	Ski adults	Ski children	SB	SB adults	SB children	All
n	342	151	191	30	18	12	372
Age mean (range)	15 (3–69)	37 (17–69)	10 (3–16)	20 (9–40)	22 (17–40)	14 (9–15)	22 (3–69
Female/male %	30/70	31/69	30/70	20/80	22/78	17/83	22/78

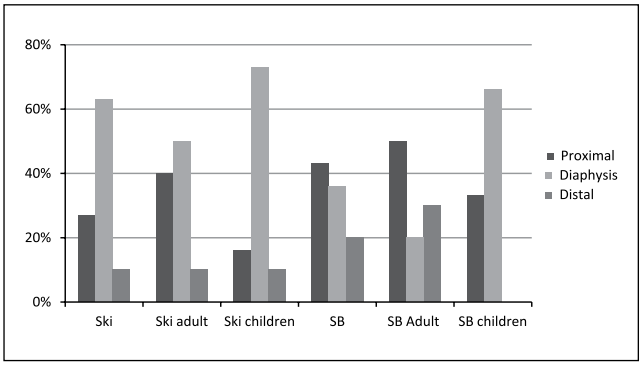

Fig. 2. Fracture location (proximal, diaphysal, distal) distribution in percentage in skiers and snowboarders.

most likely to suffer type A (n = 6) followed by type B (n = 4) and type C (n = 3). The prevalence of intra-articular tibial fractures was significantly higher in adult skiers than in children (36% (n = 55) vs 4% (n = 7), $p < 0.05$).

Type A tibial shaft fractures (n = 180) were the most common fracture type among skiers and snowboarders (n = 8). The prevalence of more complex type B and C fractures was higher in adult skiers than in children (15% (n = 23) vs 5% (n = 10), $p < 0.05$). There were no significant differences between adult and children snowboarders.

Type A distal tibial fractures (n = 22) were the most common fracture type among skiers followed by type B (n = 9) and type C (n = 4). Snowboarders were most likely to suffer type C (n = 4) followed by type B (n = 2).

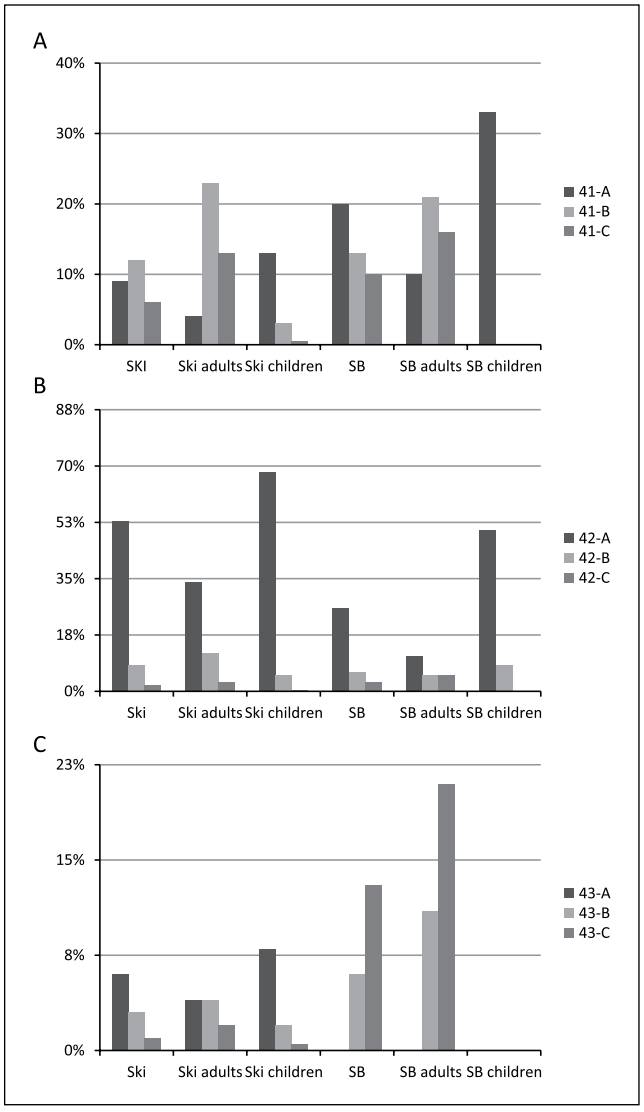

Fig. 3. A) Proximal tibial fracture (n = 92) types A–C in percentages of all tibial fractures. B) Tibial diaphyseal fracture (n = 215) types A–C in percentages of all tibial fractures. C) Distal tibial fracture (n = 35) types A–C in percentages of all tibial fractures.

The prevalence of intra-articular tibial fractures was higher in adult skiers than in children (7% (n = 9) vs 2% (n = 4), $p < 0.05$). SB children did not suffer any distal tibial fractures.

In skiers, the most common injury mechanism was loss of control and falling on the same level (238, 70%). While snowboarders were more likely to get injured due to losing control in jumping (46% (n = 14) vs 6% (n = 20), $p < 0.05$). Detailed information of fracture location and injury mechanism is presented in Table 2. Snowboarders who suffered tibial fracture due to loss of control in jump were likely to suffer AO type C tibia fracture (5, 16% of all fractures). There were no significant differences or correlation in mechanism of injury and fracture patterns between adult skiers and children.

DISCUSSION

Alpine skiing and SB share the hazards of high speed. The equipment and body mechanics of these sports are different, exposing participants to a distinct assortment of risks and different types of injuries (7).

This study indicates that the most common lower leg fracture type in skiing is the tibial shaft fracture. The results are consistent with earlier studies (8, 9). It is suggested that changes in ski equipment techniques have led to reductions in the overall injury rate, especially for ankle fractures and tibia fractures, meanwhile knee injuries and proximal tibial fractures have become more common (10–12).

Consequently, it is suggested that changes in ski equipment have changed the fracture pattern more proximally (13). Bürkner and Simmen (14) found that in 59% of all accidents causing lower extremity fracture, the binding failed to open.

The most important finding in this study was the relatively high number of the tibial plateau type B and C injuries to the proximal tibia among adult skiers. It seems that the introduction of the shorter carving ski has changed the distribution of injuries making proximal tibial fractures more common. This is clinically significant since the risk of post traumatic sequelae is higher after tibial plateau fractures involving the weight bearing joint surfaces compared to shaft fractures (15).

In this study, the proximal tibial fractures comprised almost half of the SB fractures, thus being more common than shown in recreational snowboarders on previous reports but on the same level with elite snowboarders (16, 17). It may be argued that recreational snowboarder's level of riding is relatively high in Finland resulting in increased risk taking behavior with more complex jump attempts.

We observed more than half of the tibial fractures in children (under 16 years). This study indicates that the most common lower leg fracture type in children is the tibial shaft fracture and children sustain more simple fractures than adults. Bürkner and Simmen (14) reported that young or inexperienced skiers suffer primarily from fractures of the tibial diaphysis. With increasing skiing experience, the injury pattern widens on the whole lower leg. The risk of a tibial fracture in skiing is reported to be four times higher for a child than for an adult (1). Tibia of a child is relatively weaker and will fracture with less bending and twisting than the tibia of an adult (18). In our study, over 90% of tibial shaft fractures among pediatric skiers were simple type A fractures, suggesting that tibial shaft fractures in children occurred as a result of lower energy trauma than among adult skiers or snowboarders (19). Also, our finding of low number of open fractures in children is supporting the idea of children sustaining tibial fractures probably due to lower energy trauma.

We found differences in injury mechanism and fracture type between skiers and snowboarders: snowboarders were more likely to suffer complex fractures due to loss of control while jumping compared to skiers sustaining shaft fractures due to fall on the same level. Complex proximal fractures have been associated with

TABLE 2
Tibial fracture location with related mechanism of injury in skiers and snowboarders.

	Fall on the same level	Loss of control in jump	Collision with another person	Collision with immovable object
Skiers				
Proximal	67	6	9	8
Diaphyseal	153	13	23	15
Distal	18	1	8	7
Total (100%)	238 (70%)	20 (6%)	40 (12%)	30 (9%)
Snowboarders				
Proximal	4	5	1	3
Diaphyseal	3	6	1	1
Distal	2	3	1	–
Total (100%)	9 (30%)	14 (46%)	3 (10%)	4 (13%)

Injury mechanism was unknown in 14 cases.

high energy and axial pressure with rotational forces (20). Patton et al. (21) found that snowboarders have higher proportion of fractures that involve tibia and fibula than skiers. Our results are consistent with the results of their study. It can be speculated that in the case of snowboarders, these large rotational forces may be caused by high force transmitted through non-releasing bindings while jumping. However, previous studies have shown that injuries taking place in terrain parks are more likely to be severe (22, 23).

This study has several limitations. The retrospective nature is the most prominent one. Due to the retrospective setting, we were unable to assess the exact injury mechanism (the speed or release of bindings etc.). It was also impossible to survey the degree of soft tissue injury or open fractures grading in reliable way, thus we had to leave that information out. Due to the retrospective setting, classification to skill levels was impossible. There is also a possibility of interobserver bias between assessments on fracture classification done in different hospitals, although AO-fracture classification in tibial fractures is relatively simple (24). The relatively small number of snowboarders results in decreased reliability when drawing conclusions. However, the nature of SB with tendency of performing several different jumping tricks supports our findings of tibial fractures taking place in these attempts.

In conclusion, the most important finding was the relatively high number of the tibial plateau fractures among adult skiers. The fracture patterns between SB and skiing were different; the most common fracture type in skiers was spiral tibial shaft fracture compared to proximal tibial fractures in snowboarders. The challenge to reducing the incidences of jumping related injuries is in designing safer terrain parks and jumps. We conclude in general that proper terrain park design with safety nets, signs, and adequate grooming of the jumps and landings reduces the risk of injuries. To avoid injuries, especially colliding injuries, safety should be properly underpinned in slope design to avoid collisions and to provide easier bypasses for beginners at the steeper parts of the slopes. So far, binding technologies have decreased ski-related injuries, but all skiers should be motivated to seek skiing technology professionals annually for equipment inspection. Especially with children, the proper fitting of the equipment is necessary.

DECLARATION OF CONFLICTING INTERESTS

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

FUNDING

This research received no funding from Helsinki University or grant from any funding agency in the commercial or not-for-profit sectors.

REFERENCES

1. Pajunen J, Ukkonen K: SHKY Hiihto- ja laskettelututkimus 2014. Suomen hiihtokeskusyhdistys ry, 2014, pp. 1–21. TNS 2014.
2. Blitzer CM, Johnson RJ, Ettlinger CF et al: Downhill skiing injuries in children. Am J Sports Med 1984;12(2):142–147.
3. Johnson B, Ettlinger C, Shealy JE: Update on injury trends in alpine skiing. J ASTM Int 2009;17:11–22.
4. Ekeland A, Sulheim S, Rødven A: Injury rates and injury types in alpine skiing, telemarking and snowboarding. J ASTM Int 2005;15:31–39.
5. Paloneva J: Snowboarding and alpine skiing injuries in Finland—An increased risk of wrist fractures. Suom Lääkäril 2005;60:655–659.
6. Müller ME, Nazarian S, Koch P: Classification AO des fractures. Tome I. Les os longs. Springer-Verlag, Berlin, 1987.
7. Wasden CC, McIntosh SE, Keith DS: An analysis of skiing and snowboarding injuries on Utah slopes. J Trauma 2009;67(5):1022–1026.
8. Hamada T, Matsumoto K, Ishimaru D et al: Comparison of tibial shaft ski fractures in children and adults. Clin J Sport Med 2014;24(5):380–384.
9. Flørenes TW, Nordsletten L, Heir S et al: Injuries among World Cup ski and snowboard athletes. Scand J Med Sci Sports 2012;22:58–66.
10. Shealy JE, Ettlinger CF, Johnson RJ: Using signal detection theory as a model to evaluate release/retention criteria in alpine skiing. In: Johnson RJ, Shealy JE, Ahlbaumer MG (Eds) Skiing Trauma and Safety: Fifteenth Volume (ASTM STP 1464). ASTM International,West Conshohocken, PA, 2005, pp. 1–12.
11. Burtscher M, Gatterer H, Flatz M et al: Effects of modern ski equipment on the overall injury rate and the pattern of injury location in Alpine skiing. Clin J Sport Med 2008;18(4):355–357.

12. Ruedl G, Linortner I, Schranz A et al: Distribution of injury mechanisms and related factors in ACL-injured female carving skiers. Knee Surg Sports Traumatol Arthrosc 2009;17:1393–1398.
13. Pätzold R, Spiegl U, Wurster M et al: Proximal tibial fractures sustained during alpine skiing—incidence and risk factors. Sportverletz Sportschaden 2013;27(4):207–211.
14. Bürkner A, Simmen HP: Fractures of the lower extremity in skiing—the influence of ski boots and injury pattern. Sportverletz Sportschaden 2008;22(4):207–212.
15. Honkonen SE: Degenerative arthritis after tibial plateau fractures. J Orthop Trauma 1995;9:273–277.
16. Torjussen J, Bahr R: Injuries among elite snowboarders (FIS Snowboard World Cup). Br J Sports Med 2006;40:230–234.
17. Major DH, Steenstrup SE, Bere T et al: Injury rate and pattern among Elite World Cup Snowboarders. Br J Sports Med 2014;48(1):18–22.
18. Lange J, Asang E: Comparison of the shinbone loading capacities of children and adults (International series on sport sciences). University Park Press, Baltimore, MD, 1978, p. 5.
19. Ungerholm S, Gierup J, Lindsjo U et al: Skiing injuries in children: lower leg fractures. Int J Sports Med 1985;6:292–297.
20. Schulak DJ, Gunn DR: Fractures of the tibial plateaus. Clin Orthop 1975;109:166–177.
21. Patton A, Bourne J, Theis JC: Patterns of lower limb fractures sustained during snowsports in Otago, New Zealand. N Z Med J 2010;123(1316):20–25.
22. Russell K, Meeuwisse WH, Nettel-Aguirre A, et al: Characteristics of injuries sustained by snowboarders in a terrain park. Clin J Sport Med 2013;23(3):172–177.
23. Brooks MA, Evans MD, Rivara FP: Evaluation of skiing and snowboarding injuries sustained in terrain parks versus traditional slopes. Inj Prev 2010;16(2):119–122.
24. Johnstone DJ, Radford WJ, Parnell EJ: Interobserver variation using the AO/ASIF classification of long bone fractures. Injury 1993;24(3):163–165.

Received: June 26, 2015
Accepted: August 19, 2015