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Injuries in World Cup telemark skiing: a 5-year cohort study

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Abbreviations

CI	Confidence Interval
CL	Telemark Classic
FIS ISS	International Ski Federation Injury Surveillance System
GS	Telemark Giant Slalom
OSTRC	Oslo Sport Trauma Research Center
PS	Telemark Parallel Sprint
p	p-value
RR	Relative Risk
SP	Telemark Sprint
WC	World Cup
WSC	World Ski Championship

1. Introduction

1.1 Background

Telemark skiing is a free-heel adaption of the Nordic or cross-country skiing technique to the alpine and backcountry slope. The first known telemark turns were made of Norwegians from the telemark region of Norway in the 1860`s.[1] The style experienced a revival in the 1970`s and increased in population in the nineteen nineties and beginning of the 21st century.[2-4] It is difficult to find published data on the number of telemark skiers. But, compared to alpine skiing and snowboarding telemark skiers probably account for only a minor portion of the skiing population.[5, 6]

Telemark skis have developed from ordinary cross-country skis towards skis used for alpine skiing. Boots have been transformed from low-shafted leather boots into high-shafted stiff, but still flexible boots. New bindings with release mechanism have been added to the equipment. As the telemark gear has undergone considerable technical changes during the nineties (concerning skis, bindings, boots and use of helmet) the injury pattern seem to have changed accordingly. Ankle, head, shoulder and thumb injuries have been reported most commonly,[5-11] but a decrease in ankle injuries was seen when telemark skiing equipment was modernised.[8] Other reports show an injury distribution that corresponds to injuries observed in alpine skiers with knee as the most commonly injured body part.[2, 3, 12-15]

There is limited research available in telemark skiing. Subjects are few and research has been done mainly among recreational telemark skiers. Most of the studies that have been published are not of recent date and have a low number of registered injuries. Different methods for calculating exposure have been used and only one or a few seasons have been studied. These studies should therefore be interpreted with caution. One should be aware of differences between recreational and competitive skiers and comparisons should be made with caution.

The first World Ski Championship (WSC) in telemark skiing was held 1987. Since 1995 it has been arranged by The International Ski Federation (FIS).[16] In the 2012/2013 season, 77 skiers (27 women and 55 men) received FIS WC points.[17] Knowledge of the

specific injuries by competitive telemark skiers is not known. An epidemiologic study with more precise exposure calculation would help describe injury incidence and injury pattern in elite telemark skiers. In order to prevent injuries, researchers need to discuss the magnitude, severity and causes of injury among telemark skiers. Studying WC telemark skiers throughout a 5-year period might help answer some of these questions.

1.2 The context and aims of the thesis

FIS took an initiative to establish an injury surveillance system (the FIS ISS) prior to the 2006 - 2007 winter season for all FIS events. The objective of the FIS ISS was to provide data on injury trends in international skiing and snowboarding at the elite level with the long-term goal of reducing injury risk.[18] To be able to monitor injury risk and injury pattern over time it was important to establish a continuous recording system for elite skiing and snowboarding. The FIS ISS was developed in collaboration with the Oslo Sport Trauma Research Center (OSTRC) at the Norwegian School of Sport Sciences. Studies based on data from the FIS ISS have been published for other FIS World Cup disciplines such as alpine skiing, freestyle skiing and snowboard.[19-21]

To our knowledge no previous studies have examined the injury incidence and injury pattern in WC telemark skiing. The purpose of this study was to describe the injury incidence and injury pattern among telemark skiers during 5 seasons (2008 – 2013) of the FIS World Cup.

2. History

The telemark technique developed in the Telemark region of Norway in the 1850's and was introduced in Christiania (now Oslo) in 1868.[22] From the Morgedal valley in upper Telemark in Norway, came a skier of which legendary and near-mythical status has been important in the history of skiing. Sondre Norheim is known as one of Norway's foremost skiers in the decades surrounding 1850. In 1868 he competed in a rally in Christiania and impressed with his technique and skills.[23] It is unknown if he really was the first person who carried out the telemark turn. Nonetheless he introduced skis, bindings and the telemark technique in the capital, where it received a lot of attention. He immigrated to the United States and contributed to spread the technique, development and production of skis abroad.[22] The technique is performed with the heel kept loose from the ski when making the turn and letting the downhill ski slide ahead while the rear knee is bent. The uphill ski is kept behind the forward ski in the turn.

Development of alpine skiing and new constructions of bindings in the early twentieth century made it possible to attach the heel to the binding.[24] The parallel turn gained popularity compared to the telemark turn, and the telemark style lost participants.[5] However, the telemark technique managed to hold its position as landing technique in jumping competitions and backcountry skiing where the free heel made it easier to climb mountains.[24] In the 1970's the interest in the telemark style increased and telemark skiing experienced a renaissance in the United States. It finally returned to Norway in the 1980's and regained popularity among skiers in the 1990's and beginning of the 21st century.[5] The first Norwegian Telemark Cup competition was arranged in 1984 and the first Norwegian Championship was held in 1992 in the disciplines Classic and Giant Slalom.[16] The telemark equipment became more similar to the alpine gear after a vast modernisation in the nineties.[24]

The International Telemark Committee (ITC) arranged the first World Ski Championship (WSC) in telemark skiing in 1987, and arranged the WSC from 1987 to 1995. Since then it has been arranged by The International Ski Federation (FIS).[16] Telemark skiing is not on the Olympic programme.

3. FIS World Cup Telemark

The official FIS World Cup events consist today of telemark classic (CL), telemark sprint (SP) and telemark parallel sprint (PS). The telemark giant slalom (GS) was removed as a World Cup event in 2012 and replaced with parallel sprint. The FIS World Cup is held every year during the period from July 1st to April 30th. [25] Normally the season starts in the beginning of November and lasts until the end of March.

3.1 Definitions

3.1.1 The telemark technique:

The hallmark of the telemark skiing technique is the telemark turn. The characteristic of the telemark turn is that one leg is leading into a turn in a lunge position. [2] The inner ski is the hindmost ski and the distance between the tip of the inner boot and the heel of the outer boot should be at least one boot length, measured in the direction of the ski. Telemark skiing is often referred to as free-heel skiing, and the heel of the inner ski should be clearly lifted from the ski. [26]



Figure 1. Telemark technique. The photo is taken from Nordli. [27] Permission to reproduce has been granted by Morten Nordli, 2014.

3.1.2 Definition of a 360:

One of the elements in the telemark race is called a 360. The competitor shall turn approximately 360 degrees and must at the end of the turn cross his/her own tracks. The radius of the centre of the semi-circle is from 4 meter to 6 meter. It is laid out so that the competitors are able to take the full turn without walking.[26]



Figure 3. Two athletes in a 360 during a PS race. The photo is taken from Nordli [27] Permission to reproduce has been granted by Morten Nordli, 2014.

3.1.3 The Jump:

The other defining characteristic of a telemark race is the jump. Every race has a jump. In CL and SP the height of the jump must not exceed 1.5 meter, while in PS the height limit is 1 meter.[28] Inclination should not be more than 20 degrees greater than the landing zone. The jump must follow the profile of the hill and must be suited for jumps from 5 to 30 meters. Penalties are given in seconds if a racer does not jump as far as the marked line in the snow, or if a racer fails to land in the telemark position.[28]

3.1.4 Penalties:

Passing a gate on one ski or falling through a gate gives a penalty of one second added to the total time of the competitor (max 1 penalty per turn, regardless of how many errors).[28] In World Cup telemark it is not allowed to start a turn in the telemark technique and end it as a parallel turn or vice versa. There can be no pause in transition

between turns. Failure to have telemark style can result in a time penalty of a second per gate.[28]

3.2 Telemark classic (CL)

The classic race is the longest and most unique of all the telemark races. The CL consists of a (counted in time) 60 to 70 % telemark section and a 30 to 40 % cross-country section. Each section includes obstacles such as jumps, a 360, moguls etc. There are at least one or two 360's and at least one jump and one other element. The course has a vertical drop between 250 meters and 500 meters and the average time for the best 5 senior men should be a minimum of 100 seconds.[29] The CL is a one run race. The telemark section contains turns in the telemark technique. This section includes all gates, the jump and the 360.[28] The cross-country section is the last portion of the race where no technique is specified. This section is laid in varying terrain, mostly easy uphill.[28]

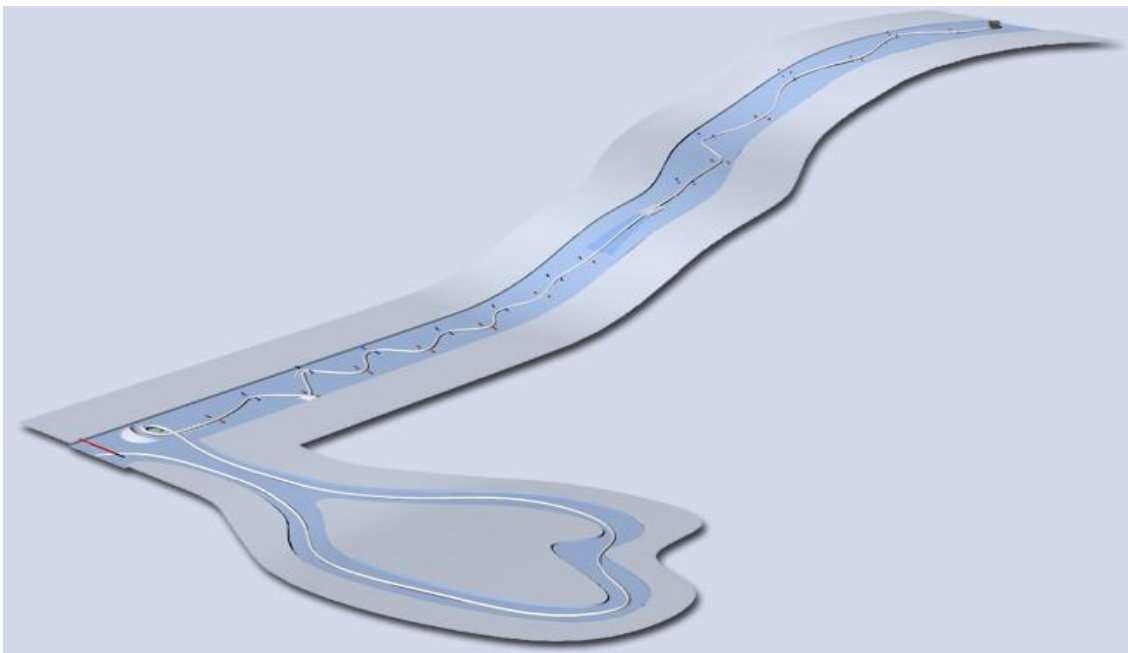


Figure 2. Telemark Classic course. The figure is taken from Nordli.[30] Permission to reproduce has been granted by Morten Nordli, 2014.

3.3 Telemark sprint (SP)

As the name infers the sprint is shorter than the classic, but in a two-run format. The course consists of 15 – 25 turns. It must include one jump, one skating section and one 360. The vertical drop is between 100 and 150 meters. The average time for the best 5

senior men is between 50 – 70 seconds. The cross-country part is placed in the last half of the course.[26]

3.4 Parallel sprint (PS)

Two competitors compete side by side down two parallel courses. The courses are as identical as possible. The course contains telemark turns, one jump, one 360 and one cross-country section. The 360 and the cross-country skiing section can be the same or separate for each course. It must be possible to view the whole course from one location (often the finish line/area) and the slope decides the length and vertical drop.

Recommended vertical drop is between 70 and 120 meters. Race time per run is approx. 30 seconds to 50 seconds.[28]

Each round has two runs, with skiers racing once in each course (red and blue). The winner of the pair (after two runs) continues to the next round.[26] The course judges indicate penalties and disqualifications (DSQ) after the 360. Such indications are displayed on panels. Penalties are indicated with 0, 1, 2, X. Where 0 means no penalty, 1 is 1 penalty, 2 means 2 penalties and X is the maximum of penalties (more than 2 or DSQ).[28]

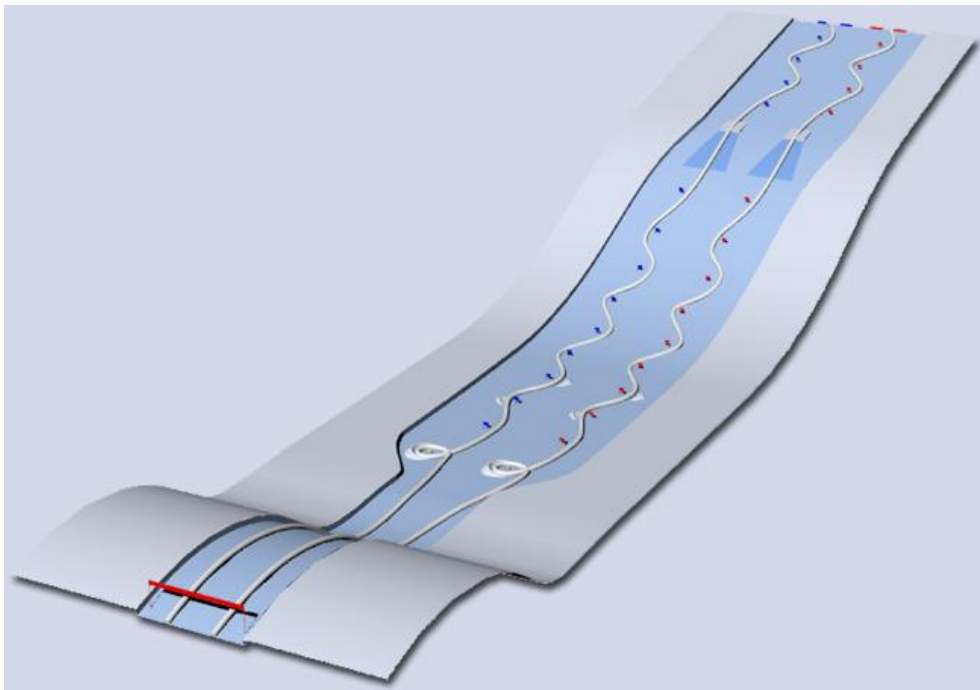


Figure 4. Telemark parallel sprint course. The figure is taken from Nordli.[30] Permission to reproduce has been granted by Morten Nordli, 2014.

3.5 Telemark giant slalom (GS)

The telemark GS is no longer a World Cup discipline. In 2012 it was removed as a WC event because telemark GS was too much like the alpine GS. Replacing GS with parallel sprint reduced this connection between telemark and alpine skiing. The telemark GS consisted of varied turns in a giant slalom course. The GS-race was a two-run race with one jump but no cross-country skiing part. The vertical drop was between 250 meters and 450 meters. The number of turns was 11 - 14 % of the vertical drop.

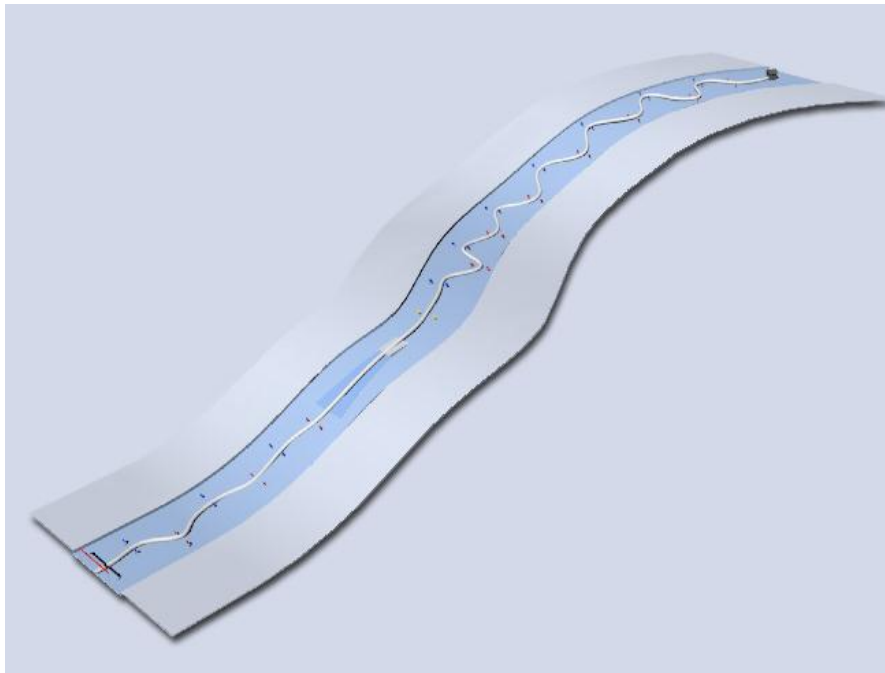


Figure 5. Telemark giant slalom course. The figure is taken from Nordli.[30] Permission to reproduce has been granted by Morten Nordli, 2014.

3.6 Equipment

The equipment has evolved from lightweight touring gear to high-performance mountaineering equipment. It is today more similar to that used in other alpine ski race disciplines, but with ski bindings fixed at the toe only and longer poles [31]. In the past the boots were of reinforced leather, but during the 90s they became more commonly made of flexible plastic shells with greater torsional rigidity and stability. The newer skis were wider and had a smaller camber (a slight upward curve in the middle of the ski) and greater responsiveness to allow more rapid, powerful turns in varied snow conditions. The bindings, which once were a simple three-pin system, developed into

more stable cable bindings that wrap around the heel of the skier's boot and attach to the ski in front of the toe. Releasable plates have been designed to separate from the ski when excessive torque is applied to the binding [2].

According to the FIS rules for World Cup telemark equipment; boots, skis and bindings must be commercially available. The boots must be made for telemark (free-heel) skiing and have a sole that is flexible under the toe ball. There are no limitations of ski measurements, however the racers competing in the World Cup use standard giant slalom skis, similar as the alpine skiers only shorter (women generally use length 175 - 180 cm and men 180 - 187 cm) and with a smaller radius (23 m radius).[32] The reasons for this are that the distances between the gates are shorter and the speed is not so high as in alpine skiing. Telemark skiers also use shorter skis because of the skating part in the end of a race.[32]



Figure 6. Telemark skis and bindings used in World Cup competitions. The picture is taken from Nordli [27] Permission to reproduce has been granted by Morten Nordli, 2014.

Bindings must be intended for telemark skiing and shall attach the toe of the boot to the ski while leaving the heel free to execute the telemark techniques. It must allow the boot to flex at the toe ball. Ski stoppers and safety straps are mandatory. It is recommended to use release bindings. Until 2012 every athlete used cable bindings. Now everyone is using the NTN (New Telemark Norm) binding system from Rottefella. This system is a departure from the 75 mm Nordic norm, there is no longer a cable around the heel and it has different attachment at the toe compared to the 75 mm duckbill. Ski poles are the

same as cross-country skiers, because of the skating part in the end of each discipline. Telemark skiers actually use longer poles than cross-country skiers because of the height of the skis and the bindings. Boots vary because of different stiffness of different models. Men tend to use a stiffer plastic boot than women. Some racers wear suits with padding on arms and legs and most racers wear back protection, but this is not mandatory. It is mandatory to wear crash helmets. Helmets with soft ear protection, as per FIS equipment specifications, are permitted in all official disciplines.[28]

The equipment among the World Cup athletes has not changed radically the last 5 years according to the coach of the Norwegian National Telemark Team[33]. There have been some small adjustments to the boots, which have become stiffer over the years. Going from bindings with cable around the heel to NTN bindings is the biggest change.

4. Concepts in epidemiological sports literature

Epidemiology is the study of the distribution and determinants of a disease or an injury in specified populations, and putting this knowledge into practise.[34] Distribution of a disease is related to the frequency and patterns of it, and its occurrence in a population. Frequency states how often a disease occurs and is typically measured as the prevalence, incidence or mortality rate of a disease.[34] Injury incidence refers to the frequency of injury and can be calculated as the rate of new cases of injuries within a time period.[34]

Evaluating injury patterns within a specified population is useful for developing hypotheses about risk factors.[34] Risk can be defined as the likelihood that people who are exposed to certain factors (risk factors), will acquire an injury.[35] These risk factors contribute to the occurrence of various events. They are often referred to as external (extrinsic) factors or internal (intrinsic) factors. The most basic expression of risk is incidence, defined as the number of new cases of diseases (injuries) arising in a defined population during a given period of time.[34]

Exposure are variables that are tested for their relationship with the outcome of interest.[34] In sport injury research exposure is often calculated as days, hours or sport-events where the athlete actually runs the risk of being injured.[36] By many researchers injury incidence is expressed as the number of injuries per 1000 hours of sports participation to enable different sports and sport persons to be compared more fairly.[36] Estimation of injury incidence in skiing events is difficult, and different methods have been used. Injury incidence among recreational skiers is often referred to as number of injures per 1000 skier days.[2, 13, 15, 37, 38] The number of ski passes sold in a period is often used to calculate the number of skiing days, however little is know about each skier's activity during the day.[39] By date there are no reports among elite telemark skiers, however, in competitive skiing and snowboarding injury incidence has been recorded per 1000 runs or per 100 athletes per season.[18-21] Flørenes et al. proposed that the injury incidence among WC ski and snowboard athletes should be recorded per 1000 competition runs.[20] This method gives an account of the number of injuries that have happened during WC competitions by counting the exact number of

runs for each athlete. Using this method enables comparisons of incidence between studies.

Estimates of the exposure-disease relationship is often expressed as the relative risk and is typically employed in cohort studies.[34] The relative risk is calculated as the ratio of referent category to different exposure levels. The null value, or no effect of the relative risk is 1.0. Values below 1.0 indicate reduced risk, whereas values above 1.0 indicate increased risk.[34]

How well statistics represent target populations vary. Confidence intervals (CI) should therefore be used.[34] A confidence interval provides an expected upper and lower limit for a statistic at a specified probability level, usually 95% or 99%. This means that the CI is a range of values on either side of the estimate which we can be 95% or 99% sure that the true values lies in between.[40] A narrow CI implies little inaccuracy and a high degree of confidence.[40] A CI provides a band within which the estimate of the population mean is likely to fall instead of a single point.[34] The probability of the result is indicated by a p-value. The smaller the p-value, the less likely the result was due to chance, and that there is an actual relationship between the variables. A value of 0.05 is the generally accepted level of significance in science. A p-value of 0.05 or less strongly suggests that you have a relationship that is not due to chance. A p-value of 0.05 indicates that in 95 cases out of hundred, the result was due to actual association, rather than chance findings.[41]

5. Injury incidence and injury patterns

There are few published studies about telemark skiing. Most of the literature concerning injury incidence are not from recent date. Some studies have described injury patterns, but do not contain information on injury incidence. Available literature includes mainly recreational telemark skiers, though some studies are from skiers in telemark skiing clubs.[2, 38] Information about the injury incidence and injury pattern in elite telemark skiing is therefore unknown. To describe general findings about injury incidence and injury patterns in telemark skiing a brief summary of available epidemiological studies is presented (Table 1).

Injury incidence and injury pattern in telemark skiing differ. Studies in telemark skiing clubs have reported 6.5 injuries and 8.9 injuries per 1000 skier days.[2, 38] Reports among recreational telemark skiers show rates of 0.9 to 10.7 injuries per 1000 skier days.[5, 13, 15, 39] Lower extremity injuries, in particular the knee is the most commonly injured body part reported among telemark skiers.[2, 3, 12-15, 38, 42] Early studies have reported ankle, head, shoulder and thumb injuries most commonly.[5-11]

Table 1: Epidemiological studies on injury rate and injury pattern in telemark skiing

Authors Publication year	Study design	Study population	Study period	Injury incidence	Injury pattern
Jorgsholm et al [11]	Cross sectional study	46 TM skiers	1989 - 1990	No info	Thumb 32%, Knee 25%, Foot 15%
Tuggy [13]	Retrospective survey	118 TM skiers	1994	10.7/1000 skier days	Knee 41%, Hip 13%, Thumb 8%
Ueland & Kopjar[14]	Prospective registration	406 TM skiers	1990 - 1996	No info	Knee 24.3%, Ankle/foot 23.3%, Lower arm/wrist/hand 22.5%
Federiuk et al[15]	Prospective survey	33 injuries; 28 TM skiers	1994-1997	4.1/1000 skier days (95/96), 1.7/1000 skier days (96/97)	Lower extremity 42%, Upper extremity 24%, Head/Facial 21%
Federiuk & Mann [3]	Retrospective survey	548 TM skiers	1997	No info	Knee 25.9%, Thumb 16.2%, Shoulder 13.4%
Rønning et al[39]	Cross sectional study	1221 TM skiers, 3 injuries	1997	0.9/1000 skier days	No info
Tuggy & Ong[2]	Retrospective survey	677 TM skiers	1996 - 1998	8.9/1000 skier days	Most common: Knee, 2nd. Thumb, 3rd. Shoulder
Ekeland & Rødven[10]	Prospective cohort	332 injured TM skiers	1996-1998	Not specified	Head 21%, Hand 18%, Knee 13%
Ekeland & Rødven[9]	Prospective cohort	485 TM skiers	1998-2000	Not specified	Head 21%, Shoulder 17%, Hand 14%
Made et al[5]	Case Control study	94 TM skiers, 115 controls	1989 - 2000	Injury ratio 1.2	Ankle/foot 28%, Knee 20%, Head/neck 17%
Sigurdsson & Adolphson[38]	Retrospective survey	113 injuries in 103 TM skiers	1999-2001	6.5/1000 skier days	Knee 41%, Trunk 14%, Thumb 13%
Sulheim et al[6]	Case Control	179 injuries, 303 controls	2002	0.96 OR	Shoulder 20.1%, Head 17.9%, Knee 14.5%
Ekeland et al[8]	Case control	368 injured TM skiers	2000-2002	Not specified	Head 19%, Shoulder 16%, Knee 13%
Ekeland & Rødven[7]	Prospective cohort	337 injured TM skiers	2002-2004	Not specified	Head 20%, Shoulder 17%, Knee 12%
Ekeland & Rødven[42]	Prospective cohort	176 injured TM skiers	2006-2008	Not specified	Knee/shoulder 19%, Head 13%, Back 11%
Ekeland & Rødven[12]	Prospective cohort	202 TM skiers	2008-2010	Not specified	Knee 26%, Head 16%, Shoulder 13%

Abbreviations: TM = telemark

6. Injury prevention

Preventing injuries is the long-term goal of epidemiological research on sport injuries. To prevent injuries among telemark skiers, knowledge about why and how injuries occur is needed. "The sequence of prevention" is a four-step injury prevention model described by van Mechelen et al. in 1992. The first step is to identify and describe the extent of the injury problem in telemark skiing. Secondly identify factors and mechanisms that play a part in the occurrence of telemark skiing injuries. The third step is introducing preventing measures to reduce future risk and severity of telemark skiing injuries based on the aetiological factors and mechanisms identified in step two. Finally the effect of measures must be evaluated by repeating the first step.[36]

The model of sport injury prevention by van Mechelen and colleagues is the most commonly cited model[43]. According to Finch there are limitations associated with this four-stage approach in the extent to which it has been implemented in practice.[43] Finch proposes a new sport injury research framework called the Translating research into injury prevention practise framework, TRIPP. This six-staged model builds on the fact that future advances in sport injury prevention will only be achieved if research efforts are directed towards understanding the implementation context for injury prevention [43]. Only research that can and will be adopted by sports participants, their coaches and sporting bodies will prevent injuries in real life.

Model stage	TRIPP	van Mechelen et al 4 stage approach [1]
1	Injury surveillance	Establish extent of the problem
2	Establish aetiology and mechanisms of injury	Establish aetiology and mechanisms of injury
3	Develop preventive measures	Introduce preventive measures
4	"Ideal conditions"/scientific evaluation	Assess their effectiveness by repeating stage 1
5	Describe intervention context to inform implementation strategies	
6	Evaluate effectiveness of preventive measures in implementation context	

Figure 7. The Translating Research into Injury Prevention Practice (TRIPP) framework for research leading to real-world sports injury prevention.[43]

6.1 Risk factors

The second step in van Mechelen and Finch's injury prevention process is to identify and elucidate factors and mechanisms causing injuries. Risk factors are often referred to as external (extrinsic) factors when they have an impact on the athlete while performing their sport. These factors include weather, visibility, snow-conditions, equipment including protective equipment (helmet, back-guards), rules, course, jumps, 360s, etc. Internal (intrinsic) factors are classified as those factors that are a part of the athlete themselves and include biomechanics, sex, skiing skill level, fatigue, conditioning, maturational stage and somatotype.[35]

A few epidemiological studies have tried to identify potential risk factors in recreational telemark skiing. Research identifying risk factors in WC telemark skiers have not been found.

By using a prospective survey among recreational skiers, Federiuk et al. reported that in 96% of the injuries, the skier was performing a telemark turn. Powder snow or heavy, wet snow were most often reported as the snow-condition when a skier got injured.[15] The results of a survey that was mailed to a sample of North American telemark skiers in 1997 assumed that the risk of severe ankle injury was increased in leather boots compared to plastic boots and that release plates had a protective effect.[3] A study from Sweden reported that high boots was protective against ankle and foot injuries.[5] During an 11-year period, all injured telemark skiers who attended a medical center in Sweden were registered and asked to fill out an injury form. A control group of non-injured telemark skiers were interviewed in the season of 1999-2000. Falls were the most common cause of injury and a higher proportion of beginners were in the injured population.[5]

Tuggy and Ong performed a population survey from 1996-1998 of North American skiers in telemark skiing clubs.[2] Their aim was to determine specific risk factors for injury. Skill level, the use of plastic boots and releasable bindings seemed to have an injury-sparing effect. They also suggested that the detached heel of the telemark binding could reduce the risk of serious knee ligament injuries.[2] Although the knee would be injured, the lack of heel fixation would allow for the ankle joint to absorb some of the torsional stress. Sigurdsson and Adolphson also wanted to identify different risk factors by sending retrospective surveys to people in telemark skiing clubs.[38] The skier's age, a higher number of skiing days, lower number of skied seasons and use of binding lifters were factors giving higher injury rates. They suggested that the use of shoes with good stability and possessing higher skills would have preventive effect. The telemark bindings needed further improvements, especially when it came to release mechanisms.

6.2 Injury mechanisms

External and internal risk factors on their own are not enough to cause injuries. All factors involved must be accounted for, both external and internal risk factors as well as the inciting event.[44] To understand the causes of injury in sports it is necessary with a precise description of the inciting event.[44] Injury mechanism is a term used to describe the inciting event. Description of the whole body and joint biomechanics

leading up to, and at the time of injury, as well as a complete description of the mechanisms for a specific injury type should take into consideration the events leading to the injury situation (skier situation).[44] The goal is to take this information and develop specific preventive measures for a specific injury or even in a specific sport. Descriptions of the inciting events, mechanisms or body and joint biomechanics have not been well investigated in telemark skiing. No previous research has studied injury mechanisms in WC telemark skiing.

A cross-sectional study from 1991 found almost twice as many thumb injuries among recreational telemark skiers compared to alpine skiers and snowboarders.[11] Jørgsholm et al. discussed that the loose heel could cause a fall in the forward direction, and that telemark skiers therefore would injure their thumbs when falling forward more often than alpine skiers. Knee injuries were common for both telemark skiers and alpine skiers in this study, and the same mechanism with external rotation and valgus of the knee was described for telemark skiers.

7. Further perspectives

In our cohort-study we have investigated the injury incidence and injury pattern in WC telemark skiing during a five-year period. This is the first step in the sequence of preventing injuries in telemark skiing. Therefore, further research should focus on methods to identify injury situations, risk factors and mechanisms as a goal for preventing injuries.

Our knowledge of injury mechanisms in telemark skiing is limited. Video of real injury situations contains important information of what took place when the injury occurred. This information can form the basis for injury prevention strategies. Further research should focus on systematic analysis of video-recording to describe the mechanisms of injuries in WC telemark skiing. Collecting high quality video material can however be a challenge since telemark is a rather small sport with less media coverage compared to alpine skiing and snowboard. As investigated in WC alpine skiing, video-analysis can help us understand the injury mechanisms by describing injury situation and the biomechanics of the whole body and in one particular joint at the specific time of injury.[45, 46]

There are limited biomechanical data reported for telemark skiing. However, Nilsson and Haugen examined knee angular displacement and extensor muscle activity during telemark skiing in a study from 2004. They wanted to evaluate strength training exercises for telemark skiers with respect to activation of the knee extensor musculature and knee angular displacement during competitive telemark skiing and during dry-land strength training exercises.[31] The study consisted of two parts, skiing a telemark ski course and specific exercises for dry-land telemark skiing, such as telemark jumps and barbell squats. Five male telemark skiers of national and international standard took part in the study. In conclusion, an adjustment of knee angular velocity during barbell squats and of knee angle amplitude during both telemark jumps and barbell squats were reported to improve specificity during training.[31] Telemark skiers spend a substantial amount of time in dry-land strength training. A large part of this training should be skiing-specific for adaption to telemark skiing. [31] Developing an exercising programme for dry-land strength training may be a preventive measure in telemark skiing.

As a result of modernisation and development of the telemark equipment, the injury pattern have become more like that in alpine skiing, with knee the most commonly injured body part. Measures that have been taken in WC alpine skiing may to some extent be reasonable preventive measures in WC telemark. Advances in equipment design could improve safety for the telemark skier. Pole-release design, advances in helmet standards, personal protective equipment and racing suits are factors that should be considered. Other factors like snow-conditions, course setting; gates, jumps and 360's as well as the athlete ability as a skier should be evaluated and addressed. It is important to have in mind the implementation of these prevention strategies into real life. Athletes and coaches must adopt these measures for a preventive effect to take place.

When preventive strategies have been introduced in WC telemark skiing, one should repeat step 1 by obtaining new data through FIS ISS to see if injury incidence, injury pattern and the severity of injuries have changed as a result of implementing injury preventive measures.

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Injuries in World Cup telemark skiing: a 5-year cohort study

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ABSTRACT

Background: The existing knowledge on injuries in World Cup (WC) telemark skiing is

limited. **Objective:** The aim of this study was to investigate and describe the injury incidence and injury pattern among WC telemark skiers during the competitive season.

Methods: Retrospective interviews with all WC athletes were conducted at the end of five winter seasons from 2008 - 2013. All acute injuries occurring in the competitive season that required attention by medical personnel were registered. If an athlete was not present, interviews with his/her coach or medical personnel were performed.

Exposure was calculated by using official results listed on the International Ski

Federation (FIS) webpages. **Results:** A total of 149 acute injuries were registered among

565 WC telemark skiers. The absolute injury incidence was 26.4 (95% CI 22.1 to 30.6)

injuries per 100 athletes per season. The absolute injury incidence was higher for

females vs. males (RR 1.49, 95% CI 1.07 to 2.08). We registered 69 injuries during the

FIS WC competitions, corresponding to a relative injury incidence of 8.2 (95% CI 6.3 to

10.1) per 1000 runs. The most frequently injured body part was the knee (21%)

followed by hand-finger-thumb (20%), ankle (13%) and shoulder/clavicle (13%). The

absolute risk of knee and shoulder/clavicle injuries was higher for females vs. males

(knee injuries RR 2.72, 95% CI 1.35 to 5.51, shoulder/clavicle injuries RR 2.55, 95% CI

1.06 to 6.14). No differences in the injury incidence between disciplines were detected.

Conclusion: The absolute risk of injury was higher for female than male telemark skiers.

The most commonly injured body part was the knee. The absolute risk of knee and

shoulder/clavicle injuries was higher for female than for male athletes.

INTRODUCTION

Telemark skiing is a relatively new competitive sport, although the telemark turn and technique have a long history. Descriptions of the characteristic turn in the lunge position with the heel rising during turns and as a landing technique dates back to the 1860s.[1] New constructions of bindings in the early 20th century made it possible to attach the heel to the binding, and therefore the parallel turn and alpine skiing techniques became more popular compared to the telemark turn. However, the telemark technique managed to hold its position as a landing technique in jumping competitions and backcountry skiing where the free heel made it easier to climb mountains.[24]

The International Telemark Committee (ITC) arranged the first World Ski Championship (WSC) in telemark skiing in 1987, and arranged the WSC from 1987 to 1995. Since then the WSC has been organised by FIS.[16] Telemark skiing is not on the Olympic programme.

The FIS WC telemark disciplines are telemark classic (CL), telemark sprint (SP) and telemark parallel sprint (PS). Telemark giant slalom (GS) was removed as a WC event in 2012 and replaced with PS. The races consist of a telemark section with obstacles such as jumps and 360's, in addition to a cross-country section. Time penalties given in seconds are designated if a racer has a lack of telemark style, if a racer does not jump as far as the line marked after the jump or fails to land in the telemark position [25]. The CL is a one run race while the SP has a two-run format.[26] In the PS racers compete side by side down two identical parallel courses. Each round has two runs, with skiers racing once in each course. The winner of the pair continues to the next round.[26] A total of 77 WC telemark skiers received FIS WC points during the 2012/2013 season.[17]

There are few published studies about telemark skiing and very little is known about the injury incidence and injury pattern among WC telemark racers. The studies that have been published include mostly recreational telemark skiers and recent data is limited.[2, 3, 5, 6, 11-15, 37, 38]

The aim of this study was therefore to investigate and describe the injury incidence and the injury pattern among FIS WC telemark skiers based on data from the FIS Injury Surveillance System (ISS).

MATERIAL AND METHODS

Study design and population

Injuries were recorded in the FIS injury surveillance system (FIS ISS) through retrospective interviews at the end of each World Cup season from 2008 to 2013. Athletes participating in the telemark WC from France, Norway, USA, Germany, Great Britain, Switzerland, Japan, The Republic of Slovenia, Sweden, Austria, Finland, Spain, Denmark, Canada and The Czech Republic were interviewed and included in the study. All included nations had a $\geq 80\%$ response rate to the athlete interviews. The included athletes were registered in the FIS database. Interviews were conducted at the end of each season in Bjorli, Norway (March 2009), La Plagne, Montchavin-Les-Coches, France (March 2010), Rjukan, Norway (March 2011) and Espot, Spain (March 2012 and 2013).

The research teams consisted of physicians or physical therapists from the Oslo Sports Trauma Research Center. All interviews were performed in person in the finishing area or during organized meetings at the competitors' hotels. A standardized interview form for each athlete was used and if the athlete reported an injury he or she was asked to complete an injury form.[47] Specific injury information from the injury form included date and place of injury, injury location, expressed as the body part injured, injury side (left/right), injury severity, expressed as number of days of absence from full participating in training and competition, injury type, injury circumstance and specific diagnosis. Information on where the injury occurred, if it was during WC/WSC competitions, official training for these competitions, other competitions, regular training on snow or basic training not on snow was recorded. If the athlete was not present in person (due to injury or other reasons) interviews with coaches, physicians or physiotherapists were conducted. The team coaches were asked to control and complete the list of athletes from their nation. Athletes who were not defined as being on the WC team were excluded (e.g. racers on the national quota). The goal was to register all injuries that occurred between November 1st (start of season) and March 31st (end of season).

Injury definition

The FIS ISS defined injuries as “All injuries that occurred during training or competition and required attention by medical personnel”. The injury definition as well as the classification of the type of injury and body part injured is based on a consensus document on injury surveillance in football.[48] The severity of the injuries is classified according to the duration of absence from training and competition. An injury is classified as slight (no absence), minimal (1 - 3 days), mild (4 - 7 days), moderate (8 - 28 days) or severe (>28 days).[48]

Exposure registration

To calculate exposure, the number of started runs by each athlete per competition for each of the five seasons was counted using the official FIS website (<http://www.fis-ski.com/>). The official results of each of the WC/WSC races during the five seasons were extracted one by one from the FIS website online into an Excel file. Variables such as date, discipline, place, sex and number of started runs were added to each of the athletes. If an athlete did not finish or was disqualified from a run, the runs up to and the run where the athlete did not finish or was disqualified in were included. The exposure data in the Excel file were transferred to our database (Oracle database 11g, Oracle Corporation, California, USA) where the exposure data was linked to the information recorded through the interviews. Total exposure, exposure for males versus females and for each of the different telemark disciplines were calculated.

Statistics

The injury incidence was expressed as the absolute injury incidence (injuries per 100 athletes per season) and the relative injury incidence (injuries per 1000 runs) with the corresponding 95% confidence intervals (CI). All injuries during training and competitions were included when calculating the absolute injury incidence, while injuries occurring only in official WC and WSC competitions were included when calculating the relative injury incidence, as the runs started (exposure) was only available for these events. Calculations were based on the Poisson model, and Z tests were used to compare injury incidence and injury patterns between groups. The risk ratio (RR) with 95% CI was computed. A two-tailed p-level of <0.05 was considered statistically significant.

RESULTS

Athletes and injuries included

Interviews with 565 world cup athletes in telemark skiing were conducted (406 men and 159 women) during five winter seasons from 2008 until 2013 (Table 1). Of these, 293 interviews (52 %) were conducted with the athletes and 272 (48 %) with their trainers, coaches or medical personnel. A total of 151 injuries were registered in the FIS ISS database. Two injuries were excluded because they occurred out of season. A total of 149 injuries were therefore included (94 male and 55 female).

Table 1 All injuries, WC injuries, interviews and exposure (runs) during all five seasons of FIS WC telemark skiing (2008 – 2013) with absolute injury rate (injuries per 100 athlete per season) and relative injury rate (injuries per 1000 runs) computed with 95% CI for the specific seasons

Season	Per 100 athlete			Per 1000 runs		
	Injuries	Interviews	Incidence	Injuries	Runs	Incidence
2008/09	47	131	35.9 (25.6 to 46.1)	25	1847	13.3 (8.2 to 18.8)
2009/10	15	123	12.2 (6.0 to 18.4)	5	1813	2.8 (0.3 to 5.2)
2010/11	39	152	25.7 (17.6 to 33.7)	15	1896	7.9 (3.9 to 11.9)
2011/12	28	84	33.3 (21.0 to 45.7)	18	1563	11.5 (6.2 to 16.8)
2012/13	20	75	26.7 (15.0 to 38.4)	6	1289	4.7 (0.9 to 8.4)
Total	149	565	26.4 (22.1 to 30.6)	69	8408	8.2 (6.3 to 10.1)

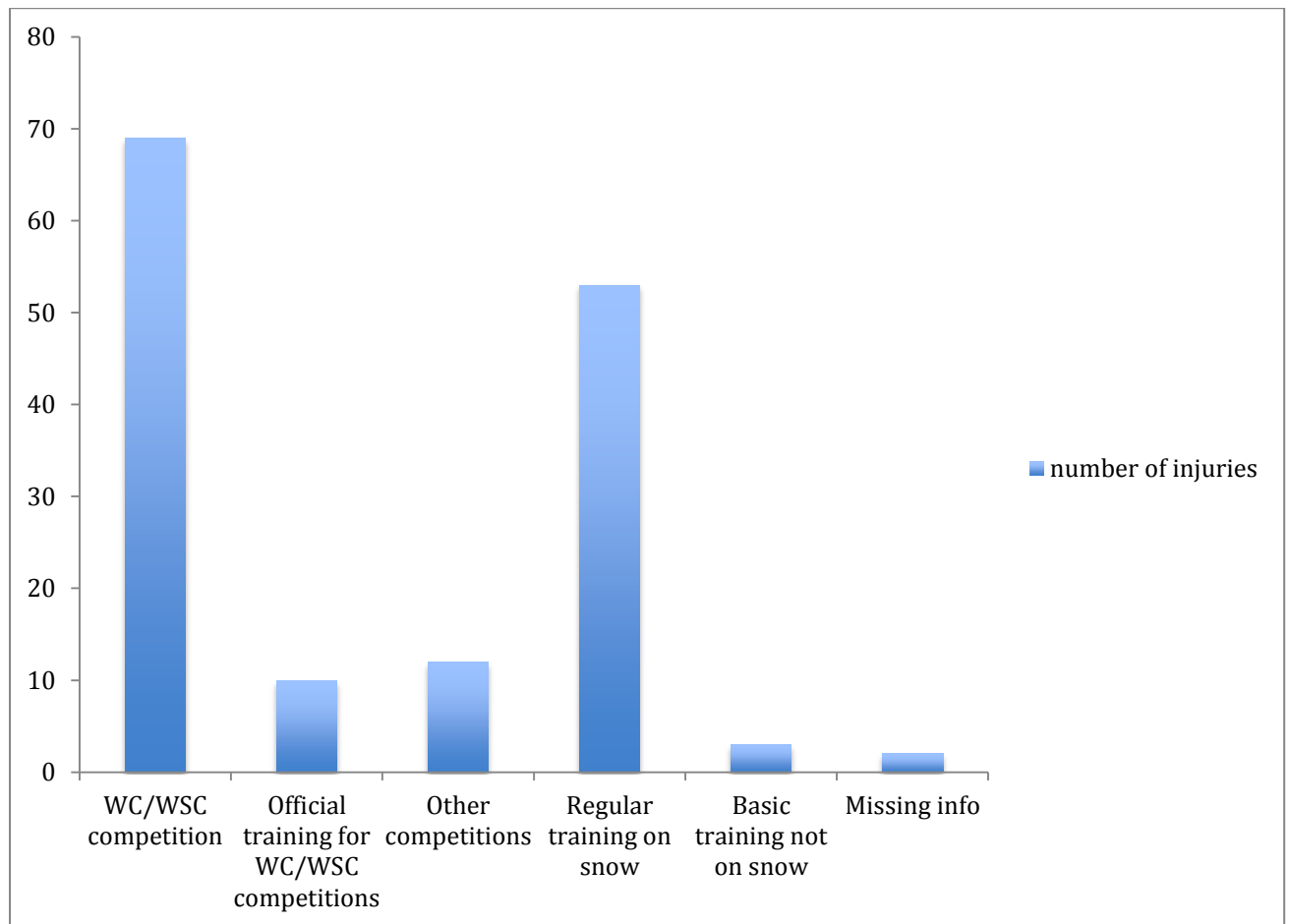
Of all injuries recorded, 71 % were time-loss injuries (n=105) leading to absence from training or competition for at least one day. Thirty-one percent of the time-loss injuries were severe, with an absence of >28 days (n=32), 26% were moderate with an absence of 8-28 days (n=27), 17% were mild with 4-7 days absence (n=18) and 27% were minimal with an absence of 1-3 days (n=28)(Table 2). For six cases data on injury severity was not available.

Table 2 All recorded injuries (n=149) with regard to body part injured and severity classified according to the number of days' absence from training and competition

Body part injured	No time loss	1 to 3 Days	4 to 7 Days	8 to 28 Days	> 28 Days	Information missing	Total (%)
Abdomen			1		2		3 (2.0)
Ankle	3	2	4	4	5	2	20 (13.4)
Chest (sternum-ribs-upper back)	1			2	2		5 (3.4)
Elbow				1			1 (0.7)
Foot-heel-toe					1		1 (0.7)
Forearm					1		1 (0.7)
Hand-finger-thumb	14	9	1	4	1	1	30 (20.1)
Head-face	4	1	4	1	1		11 (7.4)
Hip-groin	1	2				1	4 (2.7)
Knee	2	6	3	6	13	1	31 (20.8)
Lower back-pelvis-sacrum		2	1			1	4 (2.7)
Lower leg-Achilles tendon	4	2	2	2	2		12 (8.1)
Shoulder-clavicle	6	4	1	6	3		20 (13.4)
Thigh	1		1		1		3 (2.0)
Upper arm				1			1 (0.7)
Wrist	2						2 (1.3)
Total (%)	38 (25.5)	28 (18.8)	18 (12.1)	27 (18.1)	32 (21.5)	6 (4.0)	149 (100)

Of the 149 injuries included, 46% (n=69) took place during WC/WSC competitions, 6.7% (n=10) during official training for these competitions, 8.1% (n=12) in other competitions and 36% (n=53) during regular training on snow (Figure 1). In 2% (n=3) the injuries occurred during basic training not on snow, while in 1.3% (n=2) of the cases we did not have information about the circumstances of injury.

Figure 1 Distribution of all injuries (n=149) according to circumstance



Injury Incidence

The absolute injury incidence was 26.4 (95% CI 22.1 to 30.6) injuries per 100 athletes per season (Table 1). The absolute injury incidence for women was higher than for men (RR 1.49, 95% CI 1.07 to 2.08)(Table 3). For time-loss injuries the incidence was 18.6 (95% CI 15.0 to 22.1) and for severe injuries the incidence was 5.7 (95% CI 3.7 to 7.6).

Table 3 Number of injuries, interviews and runs during five seasons of FIS WC telemark skiing (2008 – 2013) with absolute injury rate (injuries per 100 athlete per season) and relative injury rate (injuries per 1000 runs) computed with 95% CI for sex

	All injuries	WC injuries	Inter-views	Runs	Incidence per 100 athlete	Risk Ratio (95% CI)	Incidence per 1000 runs	Risk Ratio (95% CI)
Males	94	43	406	5700	23.2 (18.5 to 27.8)	1	7.5 (5.3 to 9.8)	1
Females	55	26	159	2708	34.6 (25.4 to 43.7)	1.49 (1.07 to 2.08)*	9.6 (5.9 to 13.3)	1.27 (0.78 to 2.07)
Total	149	69	565	8408	26.4 (22.1 to 30.6)		8.2 (6.3 to 10.1)	

*Significant at $p < 0.05$

For the WC/WSC injuries (n=69) we calculated the injury incidence (injuries per 1000 runs) to compare injury rates between seasons, sexes and disciplines (table 1, 3, 4). The relative injury rate was 8.2 (95% CI 6.3 to 10.1) per 1000 runs. For the 69 WC/WSC injuries, there were no differences in the injury risk between disciplines or sexes (Table 3, 4).

Table 4 Number of injuries (n), exposure (runs) and relative injury incidence (expressed as the number of injuries per 1000 runs) with 95% CI for all recorded injuries and time-loss injuries (≥ 1 day absence) for the specific disciplines during five seasons (2008 – 2013) of FIS WC telemark skiing

Discipline	All injuries			Time-loss injuries (≥ 1 day)	
	n	runs	Incidence	n	Incidence
Classic	16	1237	12.9 (6.6 to 19.3)	8	6.5 (2.0 to 10.9)
Giant Slalom	18	2030	8.9 (4.8 to 13.0)	9	4.4 (1.5 to 7.3)
Sprint	29	4003	7.2 (4.6 to 9.9)	20	5.0 (2.8 to 7.2)
Parallel Sprint	6	1138	5.3 (1.1 to 9.5)	3	2.6 (-0.3 to 5.6)
Total	69	8408	8.2 (6.3 to 10.1)	40	4.8 (3.3 to 6.2)

Body part injured and severity

Almost half of all injuries were lower extremity injuries (n=71, 48%). The knee was the most commonly injured body part (n= 31, 21%) and 42% (n=13) of these injuries were

severe (Table 4). The second most frequently injured body part was hand-finger-thumb (n=30, 20%). Only one of these injuries (3.3%) was severe, and 47% (n=14) of the hand-finger-thumb injuries were slight, meaning they resulted in no absence from competition and training. Ankle injuries and shoulder/clavicle injuries both accounted for 13 % of the injuries (n=20). The absolute injury incidence for knee injuries was significantly higher for females (10.1 injuries per 100 athletes per season, 95% CI 5.1 to 15.0) vs. males (3.7 injuries, 95% CI 1.8 to 5.6, RR 2.72, 95% CI 1.35 to 5.51). There was also a significantly higher absolute rate for shoulder/clavicle injuries in females (6.3 injuries per 100 athletes per season, 95% CI 2.4 to 10.2) than in males (2.5 injuries, 95% CI 0.9 to 4.0, RR 2.55, 95% CI 1.06 to 6.14). For the other body parts injured, there were no sex differences.

DISCUSSION

This is the first cohort study to examine the injury incidence and injury pattern in WC telemark skiing. The main findings were that the absolute (per season) injury incidence was higher for female than for male telemark skiers. The knee was the most commonly injured body part and the absolute injury incidence for knee and shoulder/clavicle injuries was higher for females than for males. There was no difference in the relative or absolute injury incidence between the different disciplines.

Injury incidence

The injury incidence was calculated as the absolute incidence (the overall risk of injury to an athlete during one season) and as the relative incidence (the risk of injury per 1000 runs). The relative injury incidence was calculated for injuries in WC/WSC competitions only. In these cases the exact number of runs for each of the athletes interviewed could be calculated using the FIS webpages.

We found an absolute injury incidence of 26.4 and a relative injury incidence of 8.2. Previous studies in telemark skiing clubs have reported 6.5 injuries and 8.9 injuries per 1000 skier days.[2, 38] Reports among recreational telemark skiers show rates of 0.9 to 10.7 injuries per 1000 skier days.[5, 13, 15, 39] Determining the number of telemark skier-days can be difficult because of methodological challenges. The injury incidence in previous studies was expressed as the number of injuries per 1000 skier-days, the most common measure used for recreational skiing. We estimated the absolute (injuries per 100 athletes per season) and relative injury incidence (injuries per run). Comparisons of these results are difficult because of different injury definitions and injury registration methods used. No previous study has described the injury incidence in WC telemark skiing. However, the absolute and relative injury incidence has been reported in other FIS disciplines. Similar studies among WC alpine skiers found an absolute injury incidence of 36.7 and a relative incidence of 9.8, freestyle skiers had an absolute incidence of 44.0 and relative incidence of 15.6, while snowboarders had an absolute incidence of 40.1 and a relative incidence of 6.4.[19-21] These results show that WC alpine skiers, freestyle skiers and snowboarders have a higher absolute injury incidence than telemark skiers. Surprisingly telemark skiers have a higher relative injury

incidence than snowboarders. This might be due to telemark skiers having more injuries during WC/WSC competitions compared to snowboarders who might obtain more injuries during training on snow and in other competitions throughout the season.

Almost one third of all time-loss injuries among WC telemark skiers were severe and lead to an absence of more than 28 days. Nevertheless, alpine skiers, freestyle skiers and snowboarders have a higher incidence of severe injuries compared to telemark skiers.[19-21]

Knee injuries

The most commonly injured body part among WC telemark skiers was the knee, representing 21% of all injuries. This finding is supported by previous studies.[2, 3, 12-14, 38] Tuggy and Ong surveyed the population of telemark skiing clubs in North America and reported that knee injuries were the most common injury (27%), while Sigurdsson and Adolphson reported that out of 113 injuries in Swedish telemark skiing clubs, 36% were knee injuries.[2, 38] Ekeland and Rødven studied the injury pattern in Norwegian ski resorts from 1996 to 2008. As the telemark equipment developed, the injury pattern became more similar to that of alpine skiing injuries with the knee as the most injured part.[12] Three early reports of skiing injuries in the 1990s also showed that the knee had the highest incidence of injuries among recreational telemark skiers.[3, 13, 14]

The knee is the most commonly injured body part among WC alpine skiers, freestyle skiers and snowboarders.[18, 20, 21] Injury mechanisms have been described in alpine skiing.[46] However, because of differences in equipment and technique it is unknown if the same injury mechanisms apply in telemark skiing.

Sex differences

The absolute risk of injury to a female athlete during one season in training and competition was higher than for a male athlete. Female telemark skiers had a higher absolute risk of knee injuries. This is supported by several studies suggesting that female skiers have twice the risk of knee injuries compared with male skiers.[6-9, 12, 37,

49-51] A study on ACL injuries among young ski racers in Austria found a higher risk among women than men. Poor core strength was suggested as a critical factor.[52] Young female athletes may not be sufficiently prepared for elite ski racing, and may therefore be at higher risk of injury.[53] Ekeland and Rødven reported that knee injuries was related to skiing ability, and that the population of injured recreational female skiers had lower ability than injured males on Norwegian slopes.[12] It is not known if these explanations apply to our findings.

In contrast, Bere and coworkers did not find any difference in knee injuries between female versus male WC alpine skiers.[53] The high energy involved was suggested to cancel out potential sex-related intrinsic risk factors. Anatomical and physiological differences between women and men in WC alpine skiing would therefore have less influence on the risk of knee/ACL injuries. The energy in WC telemark skiing is probably not as high as in WC alpine skiing. Important to note is that female and male WC telemark skiers compete in the same course, unlike WC alpine skiers who have different courses for males and females. In telemark the skiers are therefore influenced by the same extrinsic factors (course length, height of vertical drop, jump, 360).

Our results are in line with Sulheim and coworkers and Ekeland and Rødven, who found a higher risk for knee injuries in female recreational skiers.[6, 12] In contrast though, their studies showed a lower risk of shoulder injuries for female skiers while our results showed a higher absolute risk for shoulder/clavicle injuries among females. Tuggy and Ong also reported that men had higher rates of shoulder injuries.[2] More cautious skiing was suggested as an explanation for why female skiers and snowboarders had a lower risk of upper limb injuries. Upper limb and head injuries were often associated with falling from a jump.[6] Recreational skiing males might jump more in the backcountry or in the slope than females, while in the WC all the telemark disciplines contain a jump. It is difficult to say whether this relates to our results, as we do not have data on how or under which circumstances the skiers got injured. Further research into the injury situations and injury mechanisms in WC telemark skiing using video analysis, would help us clarify the circumstances of injury.

Injury incidence between disciplines in telemark

We did not find any significant difference in the relative or absolute injury incidence between the different disciplines in WC telemark. Looking at the incidence for each discipline, the number of injuries was limited when assessing subgroups and the results should be interpreted with caution because of low study power.

Methodological considerations

Recall bias is a challenge when using retrospective interviews as a method for recording injuries. In this study all injury recording during the five WC seasons was through interviews with athletes, medical personnel or coaches. A methodological study found that retrospective interviews gave the most complete picture of injuries to WC skiers and snowboarders compared with prospective injury recording by team medical personnel or FIS technical delegates in this setting.[47] All interviews were performed at the end of each season and interview forms based on race schedules were used to help the interviewee remember incidents during the season. The telemark WC teams are also a close-knit community with a small number of athletes, travelling, training and living together. Despite this, we cannot guarantee that injuries haven't been under-reported due to recall bias of the interviewee. The number of skiers interviewed went down by nearly 50% from the first to the last season. We do not know the exact reason for this, but it might be a result of teams not receiving financial support and therefore cutting down on the number of athletes participating in the WC. Despite this decrease, the number interviewed has been stable for the last 3 seasons.

Telemark athletes should focus preventive training towards knee injuries based on the injury pattern observed. Evaluating whether women and men should compete in different courses is of relevance. Future studies should attempt to identify injury situations and injury mechanisms in WC telemark skiing by obtaining videos of telemark skiing injuries to describe the mechanisms involved.

CONCLUSION

The absolute risk of injury was significantly higher for female than for male telemark skiers in training and competitions. The most commonly injured body part was the knee and the absolute risk of knee and shoulder/clavicle injuries was significantly higher in female athletes as in males. There was no difference in the injury incidence between disciplines.

What this study adds to existing knowledge

- This is the first cohort study examining the injury incidence and injury pattern in WC telemark skiing.
- The knee was the most commonly injured body part and almost half of these injuries were severe.
- The absolute injury incidence for knee and shoulder/clavicle injuries was higher in females than in males.

How might it impact on clinical practise in the near future?

- Prevention strategies in WC telemark skiing should focus on knee injuries and severe injuries, with particular attention to female athletes.
- Continued research of injury situations, factors and mechanisms is needed. This can be achieved by analysing videos of injury situations.

ACKNOWLEDGEMENTS

We thank the International Ski Federation staff and officials for all practical support in collecting injury data, as well as the athletes, coaches and medical staff who participated in this study. The authors would also like to thank Tonje Wåle Flørenes, who was responsible for establishing the International Ski Federation Injury Surveillance System (FIS ISS).

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ETHICS APPROVAL

The project has been reported to the Regional Committee for Medical Research Ethics, South Eastern Norway Regional Health Authority, Norway and approved by the Social Science Data Services.

COMPETING INTERESTS

None.

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Appendix 1:



Injury Surveillance Study - Interview

World Cup, Telemark 2011/12



Athlete Name: _____

Nation: _____ Discipline: _____

Contact (e-mail/cell): _____

Trainer: _____
 MD/PT: _____
 Athlete Male
 Female

Week	Date	Site	Race / Competition	Start: Yes	Injury: Yes	If "yes" on injury, fill out form Other notes
16.-22.01.2012						
3	20.-21.01.2012	Rauris (AUT), GBR	2 x SP	<input type="checkbox"/>	<input type="checkbox"/>	CANCELLED
22.-29.01.2012						
3 and 4	22.01.2012	Bohinj, SLO	SP	<input type="checkbox"/>	<input type="checkbox"/>	
	23.01.2012		SP	<input type="checkbox"/>	<input type="checkbox"/>	
23.-29.01.2012						
4	28.01.2012	Kvitfjell, NOR	SP	<input type="checkbox"/>	<input type="checkbox"/>	
	29.01.2012		CL	<input type="checkbox"/>	<input type="checkbox"/>	
30.01.-05.02.2012						
5	02.02.2012	Rjukan, NOR	SP	<input type="checkbox"/>	<input type="checkbox"/>	
	03.02.2012		TPS	<input type="checkbox"/>	<input type="checkbox"/>	
	04.02.2012		TPS	<input type="checkbox"/>	<input type="checkbox"/>	
11.-19.02.2012						
6 and 7	13.02.2012	Steamboat, USA	CL	<input type="checkbox"/>	<input type="checkbox"/>	
	14.02.2012		CL	<input type="checkbox"/>	<input type="checkbox"/>	
	16.02.2012		SP	<input type="checkbox"/>	<input type="checkbox"/>	
	17.02.2012		TPS	<input type="checkbox"/>	<input type="checkbox"/>	
	18.02.2012		SP	<input type="checkbox"/>	<input type="checkbox"/>	
08-10.02.2011						
10 and 11	11.03.2012	Vallee de Chamonix, FRA	CL	<input type="checkbox"/>	<input type="checkbox"/>	
	12.03.2012		SP	<input type="checkbox"/>	<input type="checkbox"/>	
12.-18.03.2012						
11	16.03.2012	Espot, SPA	CL	<input type="checkbox"/>	<input type="checkbox"/>	
	17.03.2012		SP	<input type="checkbox"/>	<input type="checkbox"/>	
	18.03.2012		TPS	<input type="checkbox"/>	<input type="checkbox"/>	

Number of injuries: _____

Number of injury forms: _____

The athlete has read and understood the Athlete Information form and consents to participate in the FIS Injury Surveillance System

Athlete signature

Appendix 2



Injury Surveillance Study - World Cup Teams Interview

Oslo Sports Trauma
Research Center

Injury report / Verletzungsmeldung / Rapport de blessure

Athlete information/

Informationen zum Athleten/Données sur l'athlète

Name/ Name/Nom:

Country/
Land/Pays:

Gender/
Geschlecht/
Sexe:

 Male/ Mann/Homme
 Female/ Frau/Femme

Injury information/

Information zur Verletzung/Information sur la blessure

Discipline:

Injury 1

Date of injury:

Body part injured/ Verletzter Körperteil/Partie du corps blessée:

- Head-face/ Kopf-Gesicht/Tête-Face
- Neck-cervical spine/ Nacken-Halswirbel/Nuque-Vertèbre cervicale
- Shoulder-clavicular/ Schulter-Schultergelenk/Epaule-Clavicule
- Upper arm/ Oberarm/Bras
- Elbow/ Ellbogen/Coudes
- Forearm/ Unterarm/Avant-bras
- Wrist/ Handgelenk/Poignet
- Hand-finger-thumb/ Hand-Finger-Daumen/Main-Doigt-Pouce
- Chest (sternum-ribs-upper back)/ Brustkasten (Brustbein-Rippen-Brustwirbelsäule)/Thorax (Sternum-Côtes-Haut du dos)
- Abdomen/ Bauch/Abdomen
- Lower back-pelvis-sacrum/ Lendenwirbelsäule-Becken-Kreuzbein/Bas du dos-Pelvis-Sacrum
- Hip-groin/ Hüfte-Leiste/Hanche-Aîne
- Thigh/ Oberschenkel/Cuisse
- Knee/ Knie/Genoux
- Lower leg-Achilles tendon/ Unterschenkel-Achillessehne/Jambe-Tendon d'Achille
- Ankle/ Fussgelenk/Cheville
- Foot-heel-toe/ Fuss-Ferse-Zehen/Pied-Talon-Orteils
- Information not available/ information nicht verfügbar/information non disponible

Did you use any protection?

- Helmet
- Back/ Wirbelsäule/Dos
- Shoulder/ Schulter/Epaule
- Elbow/ Ellbogen/Coudes
- Wrist/ Handgelenk/Poignet
- Hip-pants
- Knee/ Knie/Genoux
- Leg-shin
- Teeth
- Pole-protection
- Jacket with different protection
- Other

Specific diagnosis/ Genaue Diagnose/Diagnostic spécifique:

Circumstances:

- FIS World Cup/World Championship(WCS)
- Other FIS competition
- Other competition
- Official FIS WC/WCS training
- Official FIS training
- Other training activity on snow
- Basic training, not on snow (weight lifting, running etc.)

Injury type/ Art der Verletzung/Genre de la blessure:

- Fractures and bone stress/ Frakturen und Ermüdungsbrüche/Fracture et fracture de fatigue
- Joint (non-bone) and ligament/ Gelenke (nicht Knochen) und Bänder/Joint (articulation) et ligament
- Muscle and tendon/ Muskel und Sehnen/Muscle et tendon
- Contusions/ Quetschungen/Contusions
- Laceration and skin lesion/ Fleischwunden und Hautverletzung/Plaie et lésion de la peau
- Nervous system including concussion/ Nervensystem inkl. Gehirnerschütterung/Système nerveux y compris commotion cérébrale
- Other/ Andere/Autres
- Information not available/ information nicht verfügbar/information non disponible

Absence from training and competition/ Abwesenheit von Training und Wettkämpfen/Absence à l'entraînement et en compétitions:

- No absence/ Keine Absenz/Pas d'absence
- 1 to 3 days/ 1 bis 3 Tage/1 à 3 jours
- 4 to 7 days/ 4 bis 7 Tage/4 à 7 jours
- 8 to 28 days/ 8 bis 28 Tage/8 à 28 jours
- >28 days/ >28 Tage/>28 jours
- Information not available/ information nicht verfügbar/information non disponible

Side/ Seite/Part:

- Right/ Rechts/Droite
- Left/ Links/Gauche
- Not applicable/ Nicht anwendbar/Non applicable

Injury information/

Information zur Verletzung/Information sur la blessure

Injury 2

Discipline:

Date of injury:

Body part injured/ Verletzter Körperteil/Partie du corps blessée:

- Head-face/ Kopf-Gesicht/Tête-Face
- Neck-cervical spine/ Nacken-Halswirbel/Nuque-Vertèbre cervicale
- Shoulder-clavicular/ Schulter-Schlüsselbein/Epaule-Clavicule
- Upper arm/ Oberarm/Bras
- Elbow/ Ellbogen/Coudes
- Forearm/ Unterarm/Avant-bras
- Wrist/ Handgelenk/Poignet
- Hand-finger-thumb/ Hand-Finger-Daumen/Main-Doigt-Pouce
- Chest (sternum-ribs-upper back)/ Brustkasten (Brustbein-Rippen-Brustwirbelsäule)/Thorax (Sternum-Côtes-Haut du dos)
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- Lower back-pelvis-sacrum/ Lendenwirbelsäule-Becken-Kreuzbein/Bas du dos-Pelvis-Sacrum
- Hip-groin/ Hüfte-Leiste/Hanche-Aîne
- Thigh/ Oberschenkel/Cuisse
- Knee/ Knie/Genoux
- Lower leg-Achilles tendon/ Unterschenkel-Achillessehne/Jambe-Tendon d'Achille
- Ankle/ Fussgelenk/Cheville
- Foot-heel-toe/ Fuss-Ferse-Zehen/Pied-Talon-orteils
- Information not available/ Information nicht verfügbar/Information non disponible

Did you use any protection?

- Helmet
- Back/ Wirbelsäule/Dos
- Shoulder/ Schulter/Epaule
- Elbow/ Ellbogen/Coudes
- Wrist/ Handgelenk/Poignet
- Hip-pants
- Knee/ Knie/Genoux
- Leg-shin
- Teeth
- Pole-protection
- Jacket with different protection
- Other

Specific diagnosis/ Genaue Diagnose/Diagnostic spécifique:

Circumstances:

- FIS World Cup/World Championship(WCS)
- Other FIS competition
- Other competition
- Official FIS WC/WCS training
- Official FIS training
- Other training activity on snow
- Basic training, not on snow (weight lifting, running etc.)

Injury type/ Art der Verletzung/Genre de la blessure:

- Fractures and bone stress/ Frakturen und Ermüdungsbrüche/Fracture et fracture de fatigue
- Joint (non-bone) and ligament/ Gelenke (nicht Knochen) und Bänder/Joint (articulation) et ligament
- Muscle and tendon/ Muskel und Sehnen/Muscle et tendon
- Contusions/ Quetschungen/Contusions
- Laceration and skin lesion/ Fleischwunden und Hautverletzung/Plaie et lésion de la peau
- Nervous system including concussion/ Nervensystem inkl. Gehirnerschütterung/Système nerveux y compris commotion cérébrale
- Other/ Andere/Autres
- Information not available/ Information nicht verfügbar/Information non disponible

Absence from training and competition/ Abwesenheit von Training und Wettkämpfen/Absence à l'entraînement et en compétitions:

- No absence/ Keine Absenz/Pas d'absence
- 1 to 3 days/ 1 bis 3 Tage/1 à 3 jours
- 4 to 7 days/ 4 bis 7 Tage/4 à 7 jours
- 8 to 28 days/ 8 bis 28 Tage/8 à 28 jours
- >28 days/ >28 Tage/>28 jours
- Information not available/ Information nicht verfügbar/Information non disponible

Side/ Seite/Part:

- Right/ Rechts/Droite
- Left/ Links/Gauche
- Not applicable/ Nicht anwendbar/Non applicable

Appendix 3

E-mail correspondence between Morten Nordli and the author.

Hei.

I forbindelse med master i idrettsfysioterapi skriver jeg på en oppgave hvor jeg ser på skaderate og skademønster hos World Cup telemark kjørere.

I teoridelen forklarer jeg de ulike disiplinene i WC telemark, og jeg har funnet noen flotte bilder fra et hefte hvor du skriver om telemark som idrettsgren.

Det jeg lurer på er om jeg kan få lov til å bruke dine bilder av løypene i oppgaven min? Hftet som jeg har funnet er fra 2012. Er det siste utgave?

Med vennlig hilsen
Melissa Woll Johansen

Masterstud. idrettsfysioterapi, Norges idrettshøgskole

Nordli, Morten 26. mai (for 2 dager siden)

til meg

Hei.

Det kan bruke. Tror det er siste utgave, ja.

Du finner også en del telemarksbilder som kan brukes fritt her:

<https://plus.google.com/photos/111123303021559699129/albums?banner=pwa>

Mvh Morten

