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Injuries and illnesses during the 54th FIS Nordic World Ski Championships 2023 in Planica: a prospective cohort study

Tom Kastner ,[1,2] Pierre-Eddy Dandrieux ,[3,4] Dominik Fohrmann ,[4] Florian Frohberg,[1] Matjaz Turel ,[5] Maarit Valtonen ,[6] Pascal Edouard ,[3,7] Jörg Spörri ,[8,9] Bernd Wolfarth,[1,2] Astrid Junge ,[4] Karsten Hollander [4]

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For numbered affiliations see end of article.

Correspondence to
Professor Karsten Hollander; karsten.hollander@medicalschool-hamburg.de

ABSTRACT

Objective To describe the incidence and characteristics of injuries and illnesses that occurred during the 54th Nordic World Ski Championships in Planica (Slovenia) 2023, including the disciplines of cross-country skiing, Nordic combined and ski jumping.

Methods In this prospective cohort study, national medical teams and the medical team of the local organiser collected data on a daily basis on all new, exacerbated or recurrent injuries and illnesses of the registered athletes using the IOC consensus recommendations.

Results There were 596 registered athletes (250 women, 346 men), all with access to medical services. The national medical teams covered 347 (58.2%) athletes with a response rate of 77.1%. A total of 24 injuries, corresponding to an incidence rate of 4.0 per 100 athletes (95% CI, 2.5 to 5.6), and 15 illnesses, corresponding to an incidence rate of 2.5 per 100 athletes (95% CI, 1.3 to 3.8), were reported. The lower extremities were the most common injury location (58.3%), and every second injury in this category was a knee injury. The predominant injury types were joint sprains/ligament tears (25.0%) and contusions/bruises (25.0%). A total of three concussions (12.5% of all injuries) were reported, all of them in ski jumping. Among the illnesses, infections (73.3%) were the most common aetiology, and the respiratory system (53.3%) was the most frequently affected organ system.

Conclusion Special attention should be given to knee injuries in all disciplines and concussions in ski jumping. A high proportion of the recorded illnesses were of infectious origin. The reduction in hygiene regulations after the COVID-19 pandemic could have contributed to this.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Injury and illness surveillance provides fundamental information for developing preventive measures to protect athletes' health and contributes to improving medical care at competitions by more accurately predicting potential medical problems.

⇒ The first injury and illness surveillance as part of the Nordic World Ski Championships, the most important major sporting event in Nordic skiing in addition to the Winter Olympics, took place in Oberstdorf in 2021.

WHAT THIS STUDY ADDS

⇒ During the 2023 Nordic World Ski Championships in Planica, 4.0 per 100 athletes suffered an injury. The most frequently injured body parts were the lower extremities (58.3% of all injuries), with every second injury in this category being a knee injury.

⇒ 1 in 40 athletes had an illness. The rate of infection-related illnesses increased compared with that of the 2021 Nordic World Ski Championships, which were characterised by restrictive hygiene measures as a consequence of the COVID-19 pandemic.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The results of this study are essential for developing prevention strategies based on the diagnoses and risk profiles of athletes and can help to improve the type and extent of medical services during the Nordic World Ski Championships.

⇒ Particular attention should be given to the causation of knee injuries in general and head injuries/concussions in ski jumping in particular.

⇒ The prevention of infectious diseases in all Nordic skiing disciplines remains a relevant topic for minimising athlete absences and ensuring optimal performance.

INTRODUCTION

In addition to the Winter Olympics, the Nordic World Ski Championships, which take place every 2 years, are the most important competition event for athletes in cross-country skiing, Nordic combined and ski jumping. Physical and mental health are crucial to achieving the best possible performance in this important competition in Nordic skiing. Injuries and illnesses can have a negative impact on athletes' performance and success.[1 2] Moreover, athletes may be exposed to an increased risk of injury and illness due to physical load, mental stress, travel, tight accommodations and crowded competition venues, especially

in the context of multiday championships with multiple starts.[3–5] Therefore, from both health and performance perspectives, a better understanding of injury and illness and improving their prevention are of great interest in this context.

Indeed, epidemiological studies can help to develop suitable preventative measures by improving knowledge on health problems that occur.[6] In particular, observations over several events allow conclusions to be drawn regarding the most frequent and most severe injuries and illnesses, based on which risk reductions can be made.[7] Furthermore, national and local medical teams can also receive important information about specific medical needs and thus adapt and improve medical care.[8] The IOC, which has made protecting athletes' health one of its main priorities,[9] has continuously surveyed injuries and illnesses since the 2008 Olympic Games.[10–17]

Injuries and illnesses in the three Nordic skiing disciplines (cross-country skiing, Nordic combined and ski jumping) were systematically surveyed during four Winter Olympic games from 2010 to 2022.[14–17] In 2021, surveillance of injuries and illnesses was conducted for the first time during the Nordic World Ski Championships in Oberstdorf under strict COVID-19 prevention management.[18] During this time, there have been several changes to competition formats as well as the introduction of women's competitions in ski jumping for the 2014 Winter Olympics and in Nordic combined for the 2021 Nordic World Ski Championships. This epidemiological data collection on injuries and illnesses during the Nordic World Ski Championships was continued in Planica in 2023 to expand the database and identify long-term trends.

Therefore, in the current study, we aimed to describe the incidence and characteristics of injuries and illnesses that occurred during training and competition among athletes participating in the 2023 Nordic World Ski Championships.

METHODS

Study design and overall procedure

The prospective injury and illness surveillance study during the 54th International Ski and Snowboard Federation (FIS) Nordic World Ski Championships in Planica (Slovenia) covered the period from 21 February to 5 March 2023, including 2 days of official training without competition and 11 competition days. All injuries in competition and training and all illnesses of the participating athletes that were new, exacerbated or recurrent after full recovery were recorded. The methods for recording and reporting epidemiological data on injuries and illnesses in sports, described in the related 2020 IOC Consensus Statement,[19] its snow sports-specific extension[20] and the Strengthening the Reporting of Observational Studies in Epidemiology cohort checklist,[21] were used. All national medical teams were invited to participate in this study project and to report injury and illness data of their athletes. To announce the project and provide all important information (including a description of the objective, the detailed methodology and the potential benefits), two announcement letters were sent by e-mail to the local organising committee (LOC) 2 weeks and 1 week before the Nordic World Ski Championships with the request to forward them to the national ski associations. This information was also included in the official team guide of the LOC. Information posters were displayed on-site at the competition venue, and short presentations on the research project were given during the official team meetings of the respective disciplines at the start of the World Championships. In addition, the study leader (TK) and two researchers (P-ED, DF) were on-site to answer questions about the study project and provided support in correctly recording the data. An official registration of the national medical teams did not occur.

Data on injuries and illnesses were also recorded for diagnostics and treatments in the LOC's medical base (accessible to all athletes) using standardised report forms. Direct contact was established with the LOC medical director, who briefed the on-site medical staff. The researchers also supported the data collection process here.

Definitions of injury and illness

In accordance with the IOC's consensus statement on methods for recording and reporting epidemiological data on injury and illness in sports 2020[19] and identical to the injury and illness surveillance during the 2021 Nordic World Ski Championships,[18] an injury was defined as tissue damage or other impairment of normal physical function resulting from participation in training or competition due to rapid or repetitive transfer of kinetic energy, regardless of the consequences related to absence from competition and/or training.[18 19] An illness was defined as any physical complaint or disorder that was not related to an injury, again regardless of the consequences related to the absence from competition and/or training.[18 19] All injuries and illnesses that newly occurred, exacerbated or reoccurred (after full recovery and full return to sport) during the period of the Nordic World Ski Championships in competition or training and that received medical attention should have been reported. In the case of multiple injury locations and/or types caused by one accident, only the most severe injury was reported based on the determination of the research team, considering all available clinical data.

Injury and illness report form

A standardised report form was used (see online supplemental material), which was created in accordance with the 2020 Olympic Committee's consensus statement[19] and had already been used for the 2021 FIS Nordic World Ski Championships.[18] The national medical teams were requested to report injuries and illnesses occurring to the athletes daily using the online web application 'IPrevApp' (https://iprevapp.emse.fr), as was done

for prior championships.[22] Each national medical team was provided with separate password-protected access. Editable PDFs and paper-based report forms were also provided. The reporting form was available in five languages: English, French, German, Italian and Spanish. Native speakers cross-checked the correct translation. The LOC medical team used entirely paper-based reports. A separate database entry or report form was required for each injury or illness suffered by an athlete.

Patient and public involvement

In this study, patients (athletes) were neither involved in the planning nor in the execution of the research project. The FIS athlete health unit distributed a summary of the study results to the patients and their representatives.

Equity, diversity and inclusion statement

All medical teams of registered athletes of the 54th Nordic World Ski Championships were invited to participate in this study, regardless of their gender, age, origin or culture. Two women and nine men represent authors from five European countries (Germany, France, Slovenia, Switzerland and Finland). Different professional specialties were covered (sports medicine, internal medicine, physical medicine and rehabilitation, orthopaedics, sports epidemiology, sports science and data science).

Data management and statistical analyses

Due to injuries or illnesses recorded by the respective national medical team and the LOC medical team, duplicate reports were identified by comparing the data on sex, age, nation, type of sport, date and time of injury or onset of symptoms of an illness. If athletes were treated for identical conditions by the LOC and their national medical teams, the analysis prioritised the most comprehensive data set, eliminating duplicates. Furthermore, reported injuries and illnesses that occurred before the survey period or recurrent problems that were not fully recovered at the beginning of the event were excluded. After these initial steps, descriptive analyses were conducted. Continuous variables were tested for normality, and medians and IQRs were used to summarise the results. For categorical variables, frequencies and percentages were calculated. Additionally, the incidence of injuries and illnesses was quantified as the number of cases per 100 registered athletes, along with corresponding 95% CIs.

RESULTS

Population and participation of national medical teams

A total of 596 athletes (median age 24.3 years, IQR 20.7–27.9) from 67 nations were registered for the 54th FIS Nordic World Ski Championships 2023, including 250 female (41.9%) and 346 male athletes (58.1%) in the three disciplines of cross-country skiing, Nordic combined and ski jumping. For details on the different disciplines, see table 1.

The LOC medical team and 29 national medical teams (or responsible national staff) provided the data. All athletes had access to medical services provided by the LOC. The LOC medical team reported any medical treatment of athletes at the LOC medical base. The 29 national medical teams participating in this study covered 58.2% of all registered athletes (n=347; median age 24.9 years, IQR 21.9–28.3), with the highest coverage in Nordic combined athletes (63.6%), followed by ski jumping (59.1%) and cross-country skiing (56.7%). The national teams participating in this study (ie, registered for the study) achieved a response rate of 77.1% for the daily report forms. The response rate varied by discipline, with Nordic combined achieving the highest rate at 83.3%, followed by cross-country skiing at 79.4% and ski jumping at 67.2%. The detailed response rates and athlete coverage of the national medical teams are shown in table 2.

Frequency and incidence of injuries by sex and discipline

A total of 30 injuries were reported (17 by the national medical teams, 13 by the LOC); six reports were excluded from the analysis (two due to injury data before the surveillance period and four due to duplications), meaning that **24 injuries** were included in the detailed analysis. This corresponds to an injury incidence rate of 4.0 per 100 registered athletes (95% CI, 2.5 to 5.6). The sex-specific analysis revealed the same incidence rates for female athletes (4.0 per 100 athletes; 95% CI, 1.6 to 6.4)

Table 1 Number of nations, athletes and starts at the 54th International Ski and Snowboard Federation Nordic World Ski Championships 2023 in Planica

	All	Cross-country	Nordic combined	Ski jumping
Nations	67	65	15	21
Athletes	596	381 (63.9%)	88 (14.8%)	127 (21.3%)
Female athletes	250 (41.9%)	157 (41.2%)	31 (35.2%)	62 (48.8%)
Male athletes	346 (58.1%)	224 (58.8%)	57 (64.8%)	65 (51.2%)
Starts	1712	953 (55.7%)	205 (12.0%)	554 (32.4%)
Female athletes	726 (42.4%)	422 (44.3%)	47 (22.9%)	257 (46.4%)
Male athletes	986 (57.6%)	531 (55.7%)	158 (77.1%)	297 (53.6%)

Table 2 Number of reporting nations, athlete coverage and response rate of the reporting nations, with the corresponding percentage values

	All	Cross-country	Nordic combined	Ski jumping
Reporting nations	29 (43.3%)	26 (38.8%)	10 (66.7%)	7 (33.3%)
Athletes covered*	347 (58.2%)	216 (56.7%)	56 (63.6%)	75 (59.1%)
Female athletes†	155 (62.0%)	94 (59.9%)	21 (67.7%)	40 (64.5%)
Male athletes	192 (55.5%)	122 (54.5%)	35 (61.4%)	35 (53.8%)
Response rate*	77.1%	79.4%	83.3%	67.2%

*By/of the reporting nations.
†The percentage values are given in relation to the sex and type of sport.

and male athletes (4.0 per 100 athletes; 95% CI, 2.0 to 6.1). Table 3 and online supplemental file 1 summarise the total number of injuries and the incidences for each discipline and sex.

The severity, circumstances, mechanisms and modes of onset of the injuries

The primary mechanism of injury was *acute*, with *direct contact* with an object (eg, a fall) being most frequent and accounting for 54.2% of all injuries. In terms of sex, the prevalence of this injury mechanism was 50.0% for women and 57.1% for men. *Acute non-contact* injuries accounted for 8.3% of all reported injuries. Injuries *following contact* with an object (subsequently occurring but attributable to contact with an object) were rare; such an injury was recorded in only one case and involved a female cross-country skier. There were no injuries resulting from direct contact with another athlete. One-third of the injuries (33.3%) could not be attributed to a single event and were therefore of a *repetitive* nature (eg, overuse) (online supplemental file 4).

Most injuries were characterised by a *sudden onset* with an acute mechanism (70.8%), of which 58.3% were *acute sudden onset* injuries and 12.5% were *repetitive sudden onset* injuries. As many as 20.8% were *gradual onset* injuries, and 8.3% had a mixed form of *sudden* and *gradual onset injuries*.

Overall, 45.8% of the injuries occurred during competitions, whereas 41.7% were training-related injuries. Peri-competition injuries (eg, injuries sustained during the warm-up before or the cool-down after a competition) were less frequent and occurred in only one female cross-country skier (4.2%). Two injuries (8.3%) were not further specified. Table 3 provides more detailed information divided by sex and discipline.

Most injuries did not result in time loss from sports (70.8%), whereas 29.2% were associated with time loss (table 3). Notably, five injuries (0.8 per 100 athletes; 95% CI, 0.1 to 1.6) resulted in an estimated time loss of 7 days or more. Three cases of concussion were reported, all of which occurred in ski jumping, and that each resulted in at least 14 days of time loss. The other two injuries, with an estimated time loss of more than 7 days, involved a ruptured Achilles tendon and severe muscle contusion, both in cross-country skiing.

Location and type of injuries

The lower extremities were most affected by injuries (n=14, 58.3%), seven of which were knee injuries, followed by the head (n=3, 12.5%) and the upper extremities (n=3, 12.5%). In addition, three injuries (12.5%) affected more than one body region (head/face and knee; forearm and knee; chest, hand and knee) (online supplemental file 2). The predominant injury types were joint sprains/ligament tears (n=6, 25.0%) and contusions/bruises (n=5, 20.8%) (online supplemental file 3).

Frequency and incidence of illnesses by sex and discipline

During the 54th FIS Nordic World Ski Championships 2023, 16 illnesses were reported. These consisted of 12 reports from the national teams and four reports from the LOC medical team. Due to one duplication, **15 illnesses** were included in the analysis. This resulted in an overall incidence rate of 2.5 cases per 100 athletes (95% CI, 1.3 to 3.8). Further details on the frequency of the illnesses can be found in table 4.

Severity, affected organ systems, aetiology and modes of onset of the illnesses

The impact on the athletes' ability to compete or train was quantifiable: eight cases resulted in a loss of at least 1 day, corresponding to a time loss incidence rate of 1.3 per 100 athletes (95% CI, 0.4 to 2.3). For sex, male athletes had a considerably greater time loss rate than female athletes (2.0 (95% CI, 0.5 to 3.5) vs 0.4 (95% CI, 0.0 to 1.2) per 100 athletes).

The respiratory system was most frequently affected by 53.3% (n=8) of the reported illnesses, with more men (n=7) than women (n=1) being affected. Gastrointestinal issues were the second most common, with three illnesses (20.0%). Neurological illnesses were documented in two cases (13.3%), including one case of headache with hospitalisation for a male cross-country skier and one case of unspecified vertigo in a female cross-country skier. One case involved psychiatric/psychological problems in a female cross-country skier (online supplemental file 5).

Infectious diseases were the most frequent, with 11 illnesses (73.3%), and the proportion was considerably greater among male athletes (n=9). The overall distribution by aetiology is shown in figure 1 and .

Table 3 Detailed information on the occurring injuries divided by sex and discipline, including data on time loss, circumstances and mechanisms of the injuries

	Total	Cross-country	Nordic combined	Ski jumping
Injuries n (per 100 athletes; 95% CI)				
Total injuries	24 (4.0; 2.5 to 5.6)	13 (3.4; 1.6 to 5.2)	3 (3.4; 0.0 to 7.2)	8 (6.3; 2.1 to 10.5)
Female athletes	10 (4.0; 1.6 to 6.4)	6 (3.8; 0.8 to 6.8)	1 (3.2; 0.0 to 9.4)	3 (4.8; 0.0 to 10.2)
Male athletes	14 (4.0; 2.0 to 6.1)	7 (3.1; 0.8 to 5.4)	2 (3.5; 0.0 to 8.3)	5 (7.7; 1.2 to 14.2)
Time loss injuries n (per 100 athletes; 95% CI)				
No time loss	17 (2.9; 1.5 to 4.2)	11 (2.9; 1.2 to 4.6)	1 (1.1; 0.0 to 3.4)	5 (3.9; 0.6 to 7.3)
Female athletes	7 (2.8; 0.8 to 4.8)	5 (3.2; 0.4 to 5.9)	0 (0.0)	2 (3.2; 0.0 to 7.6)
Male athletes	10 (2.9; 1.1 to 4.7)	6 (2.7; 0.6 to 4.8)	1 (1.8; 0.0 to 5.2)	3 (4.6; 0.0 to 9.7)
Time loss 1 to 7 days	2 (0.3; 0.0 to 0.8)	0 (0.0)	2 (2.3; 0.0 to 5.4)	0 (0.0)
Female athletes	1 (0.4; 0.0 to 1.2)	0 (0.0)	1 (3.2; 0.0 to 9.4)	0 (0.0)
Male	1 (0.3; 0.0 to 0.9)	0 (0.0)	1 (1.8; 0.0 to 5.2)	0 (0.0)
Time loss >7 days	5 (0.8; 0.1 to 1.6)	2 (0.5; 0.0 to 1.3)	0 (0.0)	3 (2.4; 0.0 to 5.0)
Female athletes	2 (0.8; 0.0 to 1.9)	1 (0.6; 0.0 to 1.9)	0 (0.0)	1 (1.6; 0.0 to 4.7)
Male athletes	3 (0.9; 0.0 to 1.8)	1 (0.4; 0.0 to 1.3)	0 (0.0)	2 (3.1; 0.0 to 7.3)
Circumstances n (%)				
Competition	11 (45.8)	7 (53.8)	2 (66.7)	2 (25.0)
Female athletes	4 (40.0)	3 (50.0)	1 (100.0)	0 (0.0)
Male athletes	7 (50.0)	4 (57.1)	1 (50.0)	2 (40.0)
Peri-competition	1 (4.2)	1 (7.7)	0 (0.0)	0 (0.0)
Female athletes	1 (10.0)	1 (16.7)	0 (0.0)	0 (0.0)
Male athletes	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Training	10 (41.7)	4 (30.8)	1 (33.3)	5 (62.5)
Female athletes	5 (50.0)	2 (33.3)	0 (0.0)	3 (100.0)
Male athletes	5 (35.7)	2 (28.6)	1 (50.0)	2 (40.0)
Mechanism n (%)				
Acute (non-contact)	2 (8.3)	1 (7.7)	0 (0.0)	1 (12.5)
Female athletes	1 (10.0)	0 (0.0)	0 (0.0)	1 (33.3)
Male athletes	1 (7.1)	1 (14.3)	0 (0.0)	0 (0.0)
Acute (direct contact with an object)	13 (54.2)	6 (46.2)	2 (66.7)	5 (62.5)
Female athletes	5 (50.0)	3 (50.0)	1 (100.0)	1 (33.3)
Male athletes	8 (57.1)	3 (42.9)	1 (50.0)	4 (80.0)
Acute (direct contact with another athlete)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Female athletes	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Male athletes	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Acute (subsequently occurring but attributable to contact with an object)	1 (4.2)	1 (7.7)	0 (0.0)	0 (0.0)
Female athletes	1 (10.0)	1 (16.7)	0 (0.0)	0 (0.0)
Male athletes	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Repetitive (no identifiable single event)	8 (33.3)	5 (38.5)	1 (33.3)	2 (25.0)
Female athletes	3 (30.0)	2 (33.3)	0 (0.0)	1 (33.3)
Male athletes	5 (35.7)	3 (42.9)	1 (50.0)	1 (20.0)

Table 4 Detailed information on overall illnesses and those categorised by sex and discipline, including data on time loss, the affected system and the aetiology of the illnesses.

	Total	Cross-country	Nordic combined	Ski jumping
Illnesses n (per 100 athletes; 95% CI)				
Total illnesses	15 (2.5; 1.3 to 3.8)	12 (3.1; 1.4 to 4.9)	2 (2.3; 0.0 to 5.4)	1 (0.8; 0.0 to 2.3)
Female athletes	5 (2.0; 0.3 to 3.7)	5 (3.2; 0.4 to 5.9)	0 (0.0; 0.0 to 0.0)	0 (0.0)
Male athletes	10 (2.9; 1.1 to 4.7)	7 (3.1; 0.8 to 5.4)	2 (3.5; 0.0 to 8.3)	1 (1.5; 0.0 to 4.5)
Time loss illnesses n (per 100 athletes; 95% CI)				
No time loss	7 (1.2; 0.3 to 2.0)	7 (1.8; 0.5 to 3.2)	0 (0.0)	0 (0.0)
Female athletes	4 (1.6; 0.0 to 3.2)	4 (2.5; 0.1 to 5.0)	0 (0.0)	0 (0.0)
Male athletes	3 (0.9; 0.0 to 1.8)	3 (1.3; 0.0 to 2.8)	0 (0.0)	0 (0.0)
Time loss 1 to 7 days	8 (1.3; 0.4 to 2.3)	5 (1.3; 0.2 to 2.5)	2 (2.3; 0.0 to 5.4)	1 (0.8; 0.0 to 2.3)
Female athletes	1 (0.4; 0.0 to 1.2)	1 (0.6; 0.0 to 1.9)	0 (0.0)	0 (0.0)
Male athletes	7 (2.0; 0.5 to 3.5)	4 (1.8; 0.1 to 3.5)	2 (3.5; 0.0 to 8.3)	1 (1.5; 0.0 to 4.5)
Time loss>7 days	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Female athletes	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Male athletes	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Affected organ system n (%)				
Respiratory	8 (53.3)	6 (50.0)	1 (50.0)	1 (100.0)
Female athletes	1 (20.0)	1 (20.0)	0 (0.0)	0 (0.0)
Male athletes	7 (70.0)	5 (71.4)	2 (100.0)	2 (200.0)
Gastrointestinal	3 (20.0)	2 (16.7)	1 (50.0)	0 (0.0)
Female athletes	2 (40.0)	2 (40.0)	0 (0.0)	0 (0.0)
Male athletes	1 (10.0)	0 (0.0)	1 (50.0)	0 (0)
Psychiatric/Psychological	1 (6.7)	1 (8.3)	0 (0.0)	0 (0.0)
Female athletes	1 (20.0)	1 (20.0)	0 (0.0)	0 (0.0)
Male athletes	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Neurological	2 (13.3)	2 (16.7)	0 (0.0)	0 (0.0)
Female athletes	1 (20.0)	1 (20.0)	0 (0.0)	0 (0.0)
Male athletes	1 (10.0)	1 (14.3)	0 (0.0)	0 (0.0)
Unknown/not specified	1 (6.7)	1 (8.3)	0 (0.0)	0 (0.0)
Female athletes	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Male athletes	1 (10.0)	1 (14.3)	0 (0.0)	0 (0.0)
Aetiology n (%)				
Infectious disease	11 (73.3)	8 (66.7)	2 (100.0)	1 (100.0)
Female athletes	2 (40.0)	2 (40.0)	0 (0.0)	0 (0.0)
Male athletes	9 (90.0)	6 (85.7)	2 (100.0)	1 (100.0)
Allergic	1 (6.7)	1 (8.3)	0 (0.0)	0 (0.0)
Female athletes	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Male athletes	1 (10.0)	1 (14.3)	0 (0.0)	0 (0.0)
Environmental—exercise-related	1 (6.7)	1 (8.3)	0 (0.0)	0 (0.0)
Female athletes	1 (20.0)	1 (20.0)	0 (0.0)	0 (0.0)
Male athletes	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Metabolic/nutritional	1 (6.7)	1 (8.3)	0 (0.0)	0 (0.0)
Female athletes	1 (20.0)	1 (20.0)	0 (0.0)	0 (0.0)
Male athletes	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)

Continued

Table 4 Continued

	Total	Cross-country	Nordic combined	Ski jumping
Unknown, or not specified	1 (6.7)	1 (8.3)	0 (0.0)	0 (0.0)
Female athletes	1 (20.0)	1 (20.0)	0 (0.0)	0 (0.0)
Male athletes	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)

Nine illness cases were characterised by a sudden onset, typically indicating acute infections or immediate reactions. On the other hand, four illness cases were characterised by a gradual onset, indicating potentially chronic or persistent health problems. Two cases exhibited features of both patterns.

DISCUSSION

This is the second study on injury and illness surveillance during the Nordic World Ski Championships, the most important competition event in Nordic ski sports apart from the Winter Olympics. The main findings of the study were as follows: (1) the overall incidence rate among the three Nordic skiing disciplines was 4.0 per 100 athletes for injuries and 2.5 per 100 athletes for illnesses; (2) the most frequently injured body parts were the lower extremities (58.3% of all injuries), with every second injury in this category being a knee injury; and (3) concussions in ski jumping accounted for 12.5% of all injuries and half of the injuries in this discipline.

Injuries

The overall injury incidence rate of the three Nordic skiing disciplines was 4.0 per 100 athletes. This value was lower than that of the 2021 Nordic World Ski Championships and the 2014 and 2018 Winter Olympics (4.7 to 7.2 per 100 athletes) but higher than that of the 2010 and 2022 Winter Olympics (each 3.1 per 100 athletes).[14–18]

While the upper extremities were affected less frequently (12.5%) than in 2021 (37.5%), 2018 (16.0%) and 2022 (14.2%), the lower extremities were affected more frequently (58.3%) than they were during the 2021 Nordic World Ski Championships (37.5%) and the 2018 and 2022 Winter Olympics (40.0% and 42.8%).[16–18] Joint sprains/ligament tears were the most common type of injury in 2023 (25.0%), which is comparable to the rate for the 2022 Winter Olympics (21.4%).[17] In contrast, no joint sprains/ligament tears were reported for the 2021 Nordic World Ski Championships in Oberstdorf.[18] However, these differences should be interpreted with caution due to the small number of cases. Approximately one-third (29.2%) of the injuries were associated with time loss. A comparison with the Nordic World Ski Championships 2021 and Winter Olympic Games 2022 revealed comparable time loss rates.

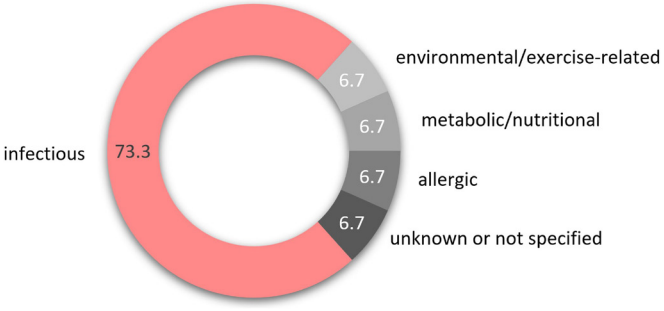

Figure 1 Distribution of aetiology of illnesses during the International Ski and Snowboard Federation Nordic World Ski Championships 2023.

A total of seven injuries, accounting for 29.2% of all injuries, affected the knee joint (three in cross-country skiing, three in ski jumping and one in Nordic combined). This represents a notable increase in knee injuries compared with those of the 2021 Nordic World Ski Championships (one knee injury in cross-country skiing) and the Olympic Games in 2018 (two knee injuries in cross-country skiing) and 2022 (one knee injury in ski jumping). The three cases of concussion in ski jumping, corresponding to an incidence rate of 4.0 per 100 ski jumpers and leading to an estimated time loss of at least 14 days each, should also be emphasised. No concussions were reported in 2010, 2018 or 2021, neither in ski jumping nor in Nordic combined, of which ski jumping is a component.[14 16 18] During the 2014 Winter Olympics, there were a total of 11 concussions across all sports represented (no more detailed information available), and in 2022, there was 1 concussion each in ski jumping and cross-country skiing.[15 17] Although the number of cases is low, preventing every single concussion is important because of the severity of the injury and the potential long-term health consequences. This demonstrates the need to review event conditions, athlete preparation, equipment and safety protocols to identify the underlying factors contributing to the increased risk of these injuries.[23–26]

A detailed representation of the injury incidence rates between the Winter Olympic Games of 2010, 2014, 2018 and 2022 and the World Ski Championships of 2021 and 2023 can be found in figure 2.[14–18]

Illnesses

The illness incidence rate of 2.5 per 100 athletes during the 2023 Nordic World Ski Championships was the lowest of all previously monitored Olympic games from 2010 to 2022 (5.9 to 10.7 per 100 athletes in the three Nordic skiing sports) and the 2021 Nordic World Championships (4.7 per 100 athletes).[14–18] Specifically, the incidence of infection-related illnesses was 1.9 per 100 athletes in the three Nordic skiing disciplines in 2023, which was

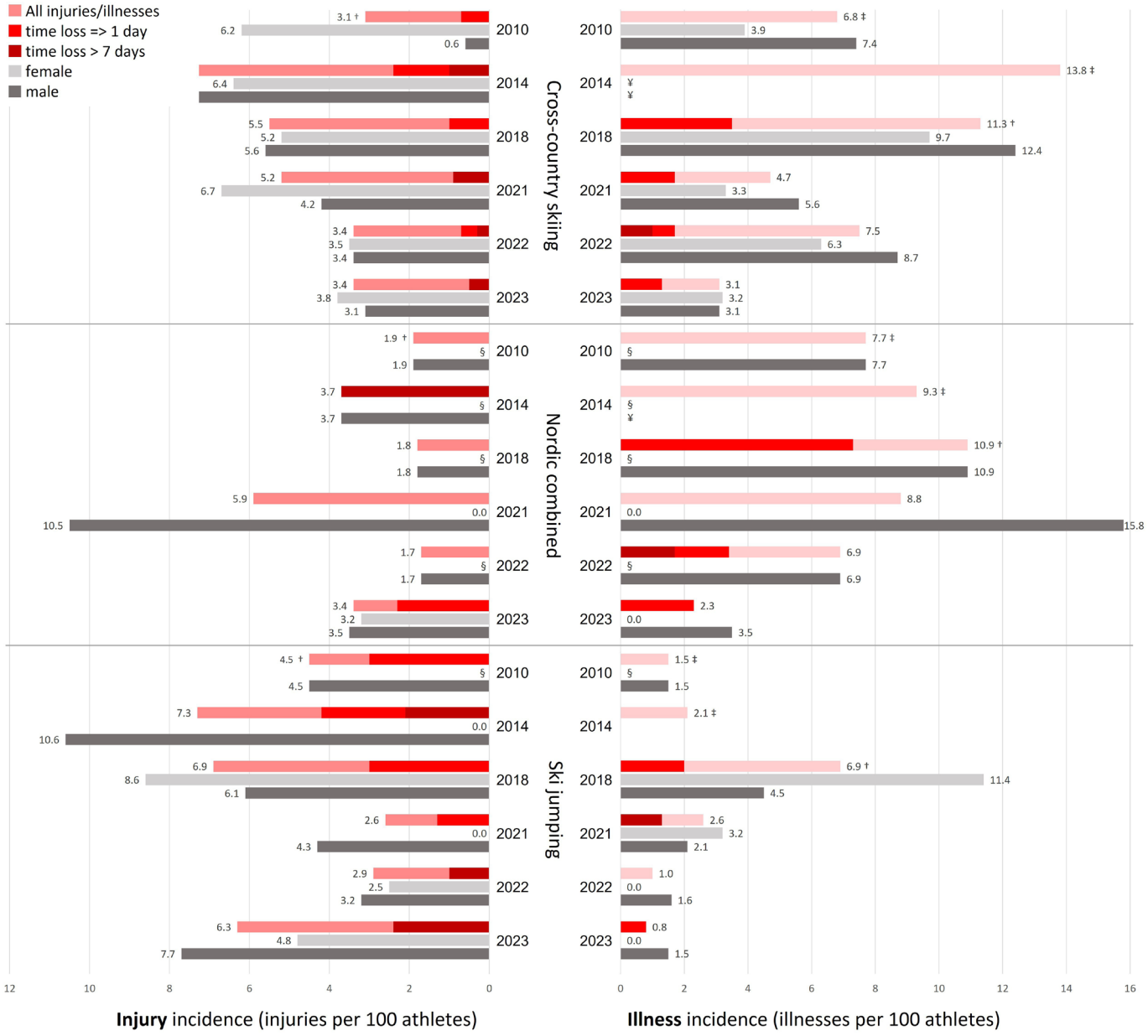

Figure 2 Overall incidence rates for injuries and illnesses, along with proportions of time loss for ≥1 day and >7 days, and incidence rates for female and male athletes in the disciplines of cross-country skiing, Nordic combined and ski jumping during the Olympic Winter Games 2010 in Vancouver, 2014 in Sochi and 2018 in Pyeongchang, and the Ski World Championships 2021 in Oberstdorf and 2023 in Planica[14–18] (†no data for time loss >7 days, ‡no data for time loss, §no women's competitions, ¥no data).

slightly greater than that in 2021 and 2022 (1.5 infection-related illnesses per 100 athletes each).[17 18] Nevertheless, compared with the pre-pandemic 2018 Winter Olympics,[16] with an infection-related illness rate of 5.8 per 100 athletes in the three Nordic skiing disciplines, the incidence for the 2023 Nordic World Ski Championships is considerably lower. While the 2021 Nordic Ski World Championships and the 2022 Winter Olympics were characterised by strict hygiene regulations, these were largely lifted in 2023. It can be assumed that the teams have adopted prevention and hygiene measures, at least in a reduced form, since the COVID-19 pandemic. However, a closer look at the aetiology of the illnesses revealed that the proportion of infection-related illnesses increased from 31.1% in 2021[18] and 25.9% in 2022[17] to 73.3% in 2023. This is accompanied by an increase in infectious illnesses of the respiratory tract. Due to the variety of possible infection symptoms and the different individual perceptions of illness, it is possible to underestimate the actual occurrence of infection.

With regard to illnesses with resulting time loss, there was a substantial increase from 31.3% in 2021 to 53.3% in 2023, although in contrast to the 2021 Nordic World Ski Championships, no time losses >7 days were reported. The questions about the cause of this increase and why male athletes are affected almost twice as often by

illnesses cannot be answered adequately. Monitoring data on the circulation of infectious diseases in the Slovenian population in the period of the 2023 Nordic World Ski Championships showed a moderate incidence of influenza diseases, a moderate-low incidence of COVID-19 diseases and a typical seasonal increase in other acute respiratory infections, with no overall peak in the abovementioned diseases.[27] However, pathogen identification of the affected athletes was not available. Figure 2 provides an in-depth analysis of the illness incidence rates observed during the Winter Olympic Games in 2010, 2014, 2018 and 2022, as well as during the World Ski Championships in 2021 and 2023.[14–18]

Methodological considerations

Due to the low number of cases within a championship, especially when considering the individual disciplines or by sex, comparisons of incidence rates and percentage distributions should be considered and interpreted with caution. The comparison of the data from the Winter Olympics and the data from the Nordic World Ski Championships should also be considered with caution. The numbers of injuries and illnesses are too low to generate (statistically) reliable statements. Furthermore, the competition programmes in the individual disciplines differ between the Nordic World Ski Championships and the Winter Olympics, for example, with different numbers of competitions, different track lengths and the exclusion of female athletes in the Nordic combined from the Olympic programme.

In studies on sports injuries and illnesses, reporting incidence rates in relation to exposure time is a common practice.[16] Due to the complex competition programme of the Nordic World Ski Championships with different disciplines, different numbers of competitions for the male and female participants in the Nordic combined, different lengths of competitions for women and men in cross-country skiing, considerable fluctuations in the individual competition frequency of the athletes and corresponding fluctuations in the length of stay at the venue, the determination of an (approximately) realistic number of athlete days was not attainable. Consequently, the absolute risk was reported as the number of new cases per 100 athletes, as it has been recommended by the snow sports-specific extension of the IOC consensus statement on recording and reporting epidemiological data on injury and illness in sports.[20]

In the second injury and illness surveillance during the Nordic World Ski Championships, all injuries and illnesses documented by the LOC medical team were included in the evaluation, in contrast to the Oberstdorf data collection in 2021, where only injuries and illnesses from the national medical teams were documented. This ensured that at least more severe health problems requiring immediate medical treatment during training or competition were recorded for athletes from teams without their own medical staff and could thus affect incidence rates.

Athlete coverage by national medical teams increased from 51.9% in 2021 to 58.2% in 2023. Nevertheless, the aim remains to achieve a higher coverage rate by the national medical teams through standardised and repeated implementation of this survey, which will provide more comprehensive insights into the health problems of athletes during these major sporting events. A complicating variable in the data collection process stemmed from the fact that some nations had different medical teams for each discipline and/or sex, whereas other nations had few or no medical teams on site. Smaller teams or nations with limited financial resources often cannot provide their own medical teams for their athletes. Although documentation could also be carried out by non-medical personnel in this case, the hurdle for this is considerably greater, presumably also due to the lack of responsibility for the field of medical tasks.

FIS did not register the national medical teams themselves, and the LOC data were not available for data protection reasons. Consequently, no statements could be made about the absolute number of medical teams on site or about their distribution in terms of nations and disciplines.

The average response rate was 77.1%, which was more than 10% lower than the 2021 Nordic World Ski Championship rate. It is possible that report forms were not submitted on days without medical issues in the respective teams, even though this is necessary to ensure data consistency and traceability. Such missing data may influence the study results.[28] Ways must be found to increase compliance among medical teams already participating in the surveillance programme.

Notably, in the case of multiple location injuries, only the most severe injury was considered. Therefore, other less severe injuries to other parts of the body were not detected. Finally, for data protection reasons, data collection was anonymised and no information on hospitalisations of athletes was available, and information on time loss was estimated by the treating medical staff. A follow-up of injured or ill athletes was not possible.

Practical implications

In the second injury and illness surveillance during the Nordic World Ski Championships, the participating national medical teams covered more athletes than they did in the first implementation in 2021, and the LOC medical team participated in the data collection. This shows the positive effects of repeated implementation and suggests increasing coverage rates for future Nordic World Ski Championships. Habituation effects due to standardised documentation processes play a major role here. The objective must also be clearly communicated to the participants, and even if concrete conclusions regarding possible prevention measures can only be drawn from several data collections, interim results of such studies must be communicated promptly and appropriately to the target groups.

The support of the international sports federation and the LOC is essential to carry out such a project and reach as many participants as possible. Due to close cooperation with the LOC medical team, even more comprehensive data collection could be achieved. This collaboration in future data collection will provide better insight into injuries and illnesses that occur. It will allow for identifying health problems that require medical attention for athletes without their own medical team on site. The official registration of national medical staff is essential for determining the medical care provided by national medical teams and for encouraging them to participate in injury and illness surveillance.

The incidence of infection-associated illnesses increased slightly compared with that in the 2021 Nordic World Ski Championships and the 2022 Winter Olympics, which were characterised by restrictive hygiene measures and low community viral pressure. Nevertheless, the incidence rate was lower than that in the 2018 Winter Olympics. Due to the largely lifted measures to protect against the transmission of infectious illnesses during the 2023 Nordic World Ski Championships, it can be assumed that specific hygiene measures have found their way into the daily practice of sports teams. However, this statement is limited by the fact that no information is available on the circulation of pathogens in the population at the respective venues, which could influence the rate of infection among athletes. Furthermore, a standardised definition for acute respiratory infections should be established to comprehensively document these infections, the most common illness in athletes.[29]

CONCLUSIONS

During the 2023 Nordic World Ski Championships, 4.0% of the athletes were injured, and 2.5% sustained an illness. Accordingly, the injury rate was lower than that of the 2021 Nordic World Ski Championships and the 2022 Winter Olympics. Nevertheless, an increase in knee injuries in the three Nordic disciplines overall and three concussions in ski jumping was particularly worrying. Although the overall incidence of illness was lower than that at the 2021 Nordic World Ski Championships, there was an increase in infection-related illnesses. The reduction in hygiene regulations may have contributed to this. Further data collection during major events in Nordic skiing is necessary to obtain more representative data and to analyse long-term changes. Close and trusting cooperation with the responsible national sports federations, international sports federations and LOCs is essential to ensure the best possible data collection.

Author affiliations
[1]Department of Sports Medicine, Institute for Applied Training Science Leipzig, Leipzig, Germany
[2]Department of Sports Medicine, Humboldt University and Charité University School of Medicine, Berlin, Germany
[3]Université Jean Monnet Saint-Etienne, Lyon 1, Université Savoie Mont-Blanc, Laboratoire Interuniversitaire de Biologie de la Motricité, F-42023, Saint-Etienne, France
[4]Institute of Interdisciplinary Exercise Science and Sports Medicine, MSH Medical School Hamburg, Hamburg, Germany
[5]University Clinical Department of Respiratory Diseases, University Clinical Centre Ljubljana, Ljubljana, Slovenia
[6]Research Center for Olympic Sports, Jyväskylä, Finland
[7]Department of Clinical and Exercise Physiology, Sports Medicine Unity, University Hospital of Saint-Etienne, Saint-Etienne, France
[8]Sports Medical Research Group, Department of Orthopaedics, Balgrist University Hospital, University of Zurich, Zurich, Switzerland
[9]University Centre for Prevention and Sports Medicine, Department of Orthopaedics, Balgrist University Hospital, University of Zurich, Zurich, Switzerland

X Tom Kastner @TomKastner5, Pierre-Eddy Dandrieux @PE_Dandrieux, Pascal Edouard @PascalEdouard42 and Karsten Hollander @k_hollander_

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Patient consent for publication Not applicable.

Ethics approval This study involves human participants and was approved by MSH Medical School Hamburg Ethics Committee (number MSH-2021/118). All athletes were informed about the project's aim and procedure, that their data are used for research, and about their right to refuse their data be used for research. All information was treated with strict confidentiality, and the anonymity of all athletes was ensured. The study was approved by the MSH Medical School Hamburg Ethics Committee (number MSH-2021/118). Furthermore, the study project was reviewed by the Ethical Committee of the Ministry of Health of the Republic of Slovenia and considered ethically uncritical. No signed informed consent was required by the ethical committees.

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ORCID iDs
Tom Kastner http://orcid.org/0000-0001-5819-7705
Pierre-Eddy Dandrieux http://orcid.org/0000-0001-7230-6728
Dominik Fohrmann http://orcid.org/0000-0002-0032-9936
Matjaz Turel http://orcid.org/0000-0002-5896-9717
Maarit Valtonen http://orcid.org/0000-0001-8883-2255
Pascal Edouard http://orcid.org/0000-0003-1969-3612
Jörg Spörri http://orcid.org/0000-0002-0353-1021
Astrid Junge http://orcid.org/0000-0002-6815-9793
Karsten Hollander http://orcid.org/0000-0002-5682-9665

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