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Snow sports-specific extension of the IOC consensus statement: methods for recording and reporting epidemiological data on injury and illness in sports

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ABSTRACT

The International Olympic Committee's (IOC) consensus statement on 'methods for recording and reporting of epidemiological data on injury and illness in sport' recommended standardising methods to advance data collection and reporting consistency. However, additional aspects need to be considered when these methods are applied to specific sports settings. Therefore, we have developed a snow sports-specific extension of the IOC statement to promote the harmonisation of injury and illness registration methods among athletes of all levels and categories in the different disciplines governed by the International Ski and Snowboard Federation (FIS), which is also applicable to other related snow sports such as biathlon, ski mountaineering, and to some extent, para snow sports. The panel was selected with the aim of representing as many different areas of expertise/backgrounds, perspectives and diversity as possible, and all members were assigned to thematic subgroups based on their profiles. After panel formation, all members were provided with an initial draft of this extension, which was used as a basis for discussion of aspects specific to the discipline, application context, level and sex within their snow sports subgroup topic. The outcomes were then aligned with the IOC's existing consensus recommendations and incorporated into a preliminary manuscript draft. The final version of this snow sports-specific extension was developed and approved in two iterative rounds of manuscript revisions by all consensus panel members and a final meeting to clarify open discussion points. This snow sports-specific extension of the IOC statement is intended to guide researchers, international and national sports governing bodies, and other entities recording and reporting epidemiological data in snow sports to help standardise data from different sources for comparison and future research.

WHAT IS ALREADY KNOWN ON THIS TOPIC?

⇒ The International Olympic Committee (IOC) published a consensus statement that provided updated recommendations on recording and reporting methods for injury and illness data across different sports and settings.

WHAT THIS STUDY ADDS?

⇒ This snow sports-specific extension of the IOC statement provides helpful guidelines for collecting and reporting epidemiological data in disciplines governed by the International Ski and Snowboard Federation (FIS).

⇒ This extension contains recommendations and example registration forms corresponding to specific snow sport disciplines, application contexts, levels and/or athlete sexes.

⇒ Although not directly addressed, this extension may be at least partially applicable to related snow sports, such as biathlon, ski mountaineering and para snow sports.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY?

⇒ The current work aims to improve data quality, enhance the comparability of data from different sources, and, in the long term, better protect the health of snow sports athletes.

INTRODUCTION

Successful protection of athlete health relies on, among other factors, sound and standardised monitoring of injury and illness epidemiology.[1] For this reason, several consensus statements have been published to promote the uniformity of methods used for recording health problems within different sports and to allow comparisons between different data sources around the globe.[2–12] In October 2020, the International Olympic Committee (IOC) released a consensus statement that provided updated recommendations on recording and reporting methods for injury and illness data across different sports and settings, hereafter referred to as the 'IOC statement'.[13 14] However, additional

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aspects need to be considered when applying this statement to specific sports, and the authors of the IOC statement encouraged the development of sport-specific extensions.[12 13] To date, such extensions have been published for tennis,[15] cycling,[16] golf,[17] circus arts[18] and football.[19] Additionally, three supplements to the IOC statement provide recommendations specific to female athlete health, mental health and para sport domains.[20–22]

The International Ski and Snowboard Federation (FIS) governs six Olympic disciplines: alpine skiing, cross-country skiing, ski jumping, Nordic combined, freestyle skiing and snowboarding. More detailed information is available on the FIS webpage (https://www.fis-ski.com/inside-fis/organisation/about-fis/facts-figures). Each discipline has unique features, such as competition formats, physical loading patterns and injury-/illness-prevention challenges, and therefore requires specific solutions for certain aspects of the methods used to record and report epidemiological data. Some features differ markedly from those of other Olympic sports and therefore require specific solutions for certain aspects of the methods used to record and report epidemiological data. FIS also manages the Para Alpine, Para Cross-Country and Para Snowboard disciplines, and is also acknowledged by the International Paralympic Committee (IPC). In contrast, biathlon and ski mountaineering are governed by the International Biathlon Unit (IBU) and the International Ski Mountaineering Federation (ISMF), respectively.

The objective of this study was to develop a snow sports-specific extension of the IOC statement with the purpose of promoting harmonisation of injury and illness registration methods among athletes of all levels and categories in the different disciplines governed by FIS. Moreover, although not directly addressed, this extension is intended to be at least partially applicable to related snow sports, such as biathlon, ski mountaineering and para snow sports. This will support international standardisation through snow sports-specific recommendations and examples, and will provide guidance to researchers, international and national federations and other entities that record and report epidemiological data in the snow sports context.

METHODS

Panel selection

The FIS Athlete Health Unit (AHU) mandated the first author (JSP) to advance the international standardisation of injury and illness registration methods and to chair the current consensus process. The last author (EV) was a core member of the IOC statement and coauthor of two sport-specific extensions and its female athlete health supplement[13–16 20] and acted as the senior investigator and supervisor in the current project. In consultation with EV, JSP selected a consensus group panel of 28 members. The background of the panel members, the reasons for their selection to the panel and their assignment to subgroups and roles with specific contributions during the consensus process are outlined in the online supplemental material file A. All panellists were researchers, National Ski/Snowboarding Association (NSSA) staff members, team medics, team physiotherapists or former top world-class athletes dealing with injury and illness surveillance in snow sports and/or with extensive experience within their assigned subgroup topic.

Equity, diversity, and inclusion statement

The composition of the panel was well balanced in terms of sex (12 females and 15 males), background (education, professions, snow sports disciplines, application contexts and competition levels) and leading snow sports nationalities. Although some people (eg, those from Middle and Eastern Europe, Asia, the Commonwealth or South American countries) may be underrepresented, the main reason for this is their absence from snow sports in general rather than biased panel selection. However, why these people find less access to snow sports in general is beyond the scope of this study. Of the leading snow sports nations in Asia, countries such as Japan and China were unfortunately not represented. The coaches' perspective (although only marginally involved in injury surveillance) may also be underrepresented. No active coaches were represented on the panel; however, some panel members had coaching education and/or previous coaching experience.

Patient and public involvement

To foster active patient and public involvement, a former top world-class athlete and representative of the IOC Athletes' Commission (AUJ) was selected to be part of the consensus panel. She contributed her practical athlete's perspective and her medical perspective as a current physician. Her role was thus to convey the athletes' voice and simultaneously to build potential bridges between sport, medicine and science.

Evidence review

The current snow sports-specific extension was established based on the IOC statement, the five sport-specific extensions and its female athlete health, mental health and para sport supplements.[13–22] Relevant literature reviews[23–33] and original publications from the last 5 years focusing on epidemiological data were identified by the panel chair based on a PubMed search dated 18 August 2022. For this purpose, the key terms alpine ski*[34–51]

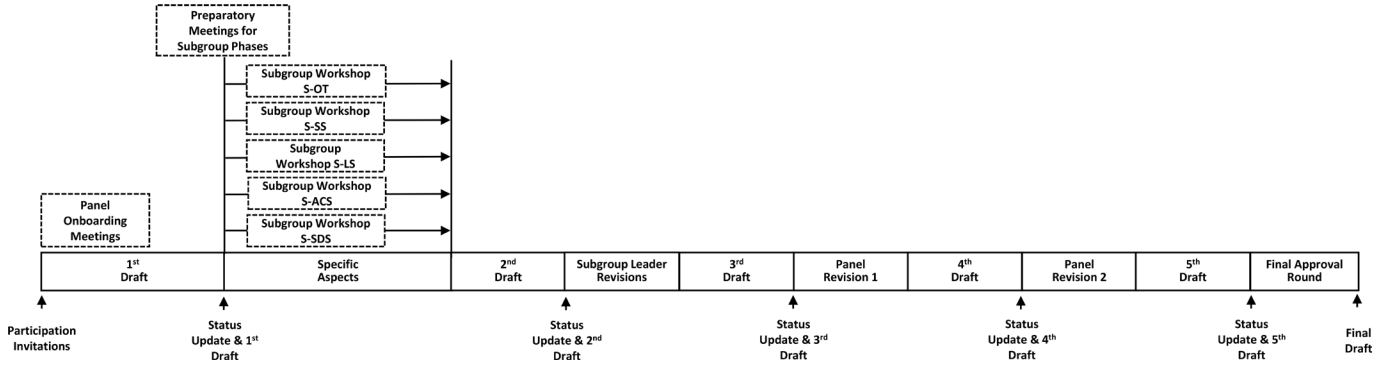

Figure 1 Consensus process and timeline. S-ACS: subgroup—application context specifics; S-LS: subgroup—level specifics; S-OT: subgroup—overarching topics; S-SDS: subgroup—snow sports discipline specifics; S-SS: subgroup—sex specifics.

Table 1 Snow sports-specific additions/modifications to the 'IOC consensus statement: methods for recording and reporting of epidemiological data on injury and illness in sport'

Topic	Additions
Defining and classifying health problems	Snow sports-specific examples of different modes of injury/illness onset, as classified by their form of presentation and the underlying mechanisms are presented (table 2). Recommendations regarding snow sports-specific descriptors for describing injury occurrence are provided (table 3).
Classifying sports injury and illness diagnoses	Minimum standard: (1) classifying injuries by body areas, and (if reported by medical staff) tissue type and pathology type; (2) noting the symptoms (if reported by medical staff) the related organ system/region and aetiology; (3) where possible, classifying injury and illness diagnoses using the OSIICS or SMDCS; (4) in cases where these systems do not provide specific enough diagnoses for the context of snow sports, using the closest possible code with the medical staff also recording the exact diagnosis separately. Snow sports-specific examples are presented (in-text).
The severity of health problems	If athletes' self-reported data are available, we recommend using consequence measures, such as the OSTRC-H2 *severity score*. If not, time loss may be used as the severity descriptor of choice in the snow sports context. However, we suggest using a more nuanced categorisation: *full*, *partial* and *no* time loss. Snow sports-specific examples are presented (table 4).
Capturing and reporting athlete exposure	Recommendations concerning the specific use of exposure measures in relation to the snow sports discipline, age/sex/level and application context (table 5). To allow comparison of injury and illness rates across all sports and application contexts, we recommend the use of the gross exposure estimate *per 100 athletes per season* as a minimum capturing and reporting standard across different snow sports disciplines and application contexts. One season refers to 1 year/12 months/365 days. More detailed/sport-specific exposure measures may be indicated depending on the purpose, provided the exposure can be exactly determined. We recommend that exposure be captured and reported separately by *activity type* (ie, off-snow training, on-snow training and competitions) and by *subcontent* (eg, endurance, strength, skill and speed, agility and complementary training).
Reporting measures of occurrence	As the preferred measure of incidence in snow sports, we recommend expressing injury/illness rates as *the number of injuries or illnesses per 100 athletes per season*. For gradual-onset health problems, the period prevalence should be expressed as *the number of injured or ill athletes per 100 athletes per season*. One season refers to 1 year/12 months/365 days. Depending on the purpose of surveillance, more specific exposure denominators may be useful for monitoring specific injuries (but not illnesses). We encourage separately reporting these rates for the *competition season period* (approximately November to April) and a *preseason period* (approximately May to October).
The burden of health problems	We encourage national skiing and snowboarding associations to systematically record and report injury and illness burden (defined as the cross-product of incidence and severity) along with the associated costs.
Study population characteristics	Snow sports-specific definitions of *elite*, *subelite* and *recreational* athletes are added. The minimum descriptors for the study population are *age*, *sex* and *level of competition*. The latter shall be described by the most frequently participated *competition format* and the athlete's *training/performance calibre*. Common terminology for the subfeatures of these descriptor categories is suggested.
Data collection methods	For injury/illness surveillance conducted in snow sports as part of national and international sports association initiatives, we recommend combining athlete-reported and staff/physician-reported data as an ideal complementary approach. Depending on the context of the application (eg, injury surveillance by international governing bodies, at events or ski resorts), level or sex, alternative or more sophisticated methodological approaches may be indicated. References to example reporting forms and illustrative example data of how to report injuries and illnesses according to the recommendations of the IOC statement and this snow sports-specific extension are presented (tables 6 and 7).

IOC, International Olympic Committee; OSIICS, Orchard Sports Injury and Illness Classification System; OSTRC-H2, Oslo Trauma Research Centre Questionnaire on Health Problems, version 2; SMDCS, Sports Medicine Diagnostic Coding System.

OR cross-country ski*[52–64] OR ski jump*[65 66] OR freestyle ski*[67] OR snowboard* were used. Eligible studies presented data from the competitive sports context. Six additional literature references were provided to the panel members via the repository later during the consensus process (PubMed search dated 12 July 2023);[33 51 62–64 68] another four were provided at the final stage of the process (PubMed search dated 16 May 2024).[69–72] To provide the panellists with an impression of the current evidence and contemporary practices in relation to the registration and reporting of injuries and illnesses (and related issues) in snow sports, these articles were made available to the panel members in a digital data repository at the beginning of the consensus process. Owing to the small number of relevant articles identified, we decided not to systematically summarise the evidence, as the current body of knowledge is limited and therefore relatively simple to overview.

Consensus process

Figure 1 illustrates the consensus process. Following an initial invitation e-mail to participate in the consensus process at the beginning of July 2022, panel formation was performed by several virtual onboarding meetings or individual calls. In parallel, JSP and EV drafted the first version of the manuscript and identified key methodological considerations for recording and reporting epidemiological data on injury and illness in snow sports, which we discussed and further elaborated on within the subgroups. The subgroup leaders (MG, KW, LS-M and MM) were presented with their work tasks during a preparatory meeting; the corresponding subgroups then met independently in virtual workshops to establish recommendations for their area. The subgroup leaders summarised the inputs provided by their subgroup members, and JSP (in consultation with KMG, BC and EV) incorporated them into a second manuscript version. After the virtual subgroup workshops and the synthesis of all inputs, there were no substantial changes to the content of the previously developed and agreed-upon recommendations. During three subsequent rounds of revisions (subgroup leader revision, panel revision 1 and panel revision 2; see figure 1), subgroup leaders and all panellists provided written feedback on the manuscript (ie, based on tracked changes) until all authors approved the final version of the manuscript. These three rounds of revision consisted primarily of feedback concerning the presentation of content and exemplary illustration, as well as formal corrections.

Table 2 Snow sports-specific examples for the injury/illness onset mode

Health problem	Mechanism	Presentation	Snow sports-specific examples
Injury	Acute	Sudden onset	► While turning, an alpine skier becomes inwardly off balance and loses snow contact with the outer ski; then, while trying to regain grip, the ski edge abruptly catches the snow surface, forcing the knee into valgus and internal rotation. The skier feels pain once back at the hotel and the knee starts swelling. MRI shows a rupture of the anterior cruciate ligament. ► A snowboarder lands with their chest on the edge of the halfpipe and immediately feels local pain. X-ray shows a rib fracture. ► A cross-country skier slips out on a downhill curve and falls onto the right shoulder, which dislocates.
	Repetitive	Sudden onset	► A ski jumper suffers from acute lower leg pain after landing a long jump. The athlete was exposed to excessive repetitive ski jump activities in the preceding months. CT imaging shows a fibular stress fracture. ► An alpine skier trains for several days on water-injected slopes with a newly fitted ski boot. During the last slalom run of the day on a bumpy course, the athlete suffers from a hard contact between the shin and the tongue of the ski boot. The athlete feels acute pain in the front shin (shin-bang) but continues skiing for the next few days. The repeated pressure of the painful area against the ski boot does not allow any healing during the entire season. ► A mogul skier with degenerative discopathy suffers from sciatica or excluded hernia during a competition run.
	Repetitive	Gradual onset	► An aerial skier reports a gradual increase in lower back pain throughout the competition season. MRI shows degenerative changes in a lumbar spine disc. ► As part of physical training, a ski jumper relies increasingly on plyometric jumping exercises. Over the summer, anterior knee pain gradually increased during sports activity. Manual palpation of the proximal patellar tendon elicits pain, and MRI reveals morphologic changes in the same area; diagnosis: Jumper's knee. ► A young cross-country skier substantially increasing their overall training load suffers progressively from cramping pain, tightness, swelling and loss of sensation in the right leg when exercising; diagnosis: chronic exertional compartment syndrome.
Illness	Acute	Sudden onset	► An elite snowboard-cross athlete suddenly suffers from gastrointestinal problems such as vomiting and diarrhoea after eating lunch in a restaurant with inadequate hygiene measures.
	Repetitive	Sudden onset	► A Nordic combined athlete with a history of exercise-induced bronchoconstriction suddenly experiences respiratory problems during competition.
	Repetitive	Gradual onset	► A cross-country skier with a known pollen allergy travels to a training camp and feels increasingly sluggish after arrival with itchy eyes, runny nose and episodic sneezing.

X-ray, radiography.

CONSENSUS RECOMMENDATIONS

An overview summarising the snow sports-specific additions/modifications to the IOC statement is presented in table 1. These additions address the fundamental topics of the IOC statement and the particular aspects highlighted where snow sports-specific recommendations may be needed.[13 14]

Defining and classifying health problems

For recommendations on defining injury and illness, we consider the IOC statement and its female athlete, mental health and para sport supplements to be fully applicable to the snow sports context.[13 14 20–22] A health problem is defined as any condition that reduces an athlete's normal state of full health, irrespective of its consequences for the athlete's sports participation or performance or whether the athlete seeks medical attention.[13 14] Given the remarkably high rates of minor sudden-onset injuries and gradual-onset injuries in some snow sports disciplines,[41 47] and given the frequent occurrence of mild respiratory infections, non-infectious respiratory illnesses such as lower airway dysfunction and related illnesses in cross-country skiing,[53 54 58 61] this wide definition is appropriate. This is especially important because severe sudden-onset injuries have typically been the major focus of injury surveillance programmes of national and international alpine skiing and snowboarding associations. For the areas of relationship to sports activity, 'multiple events and health problems', and 'subsequent, recurrent or exacerbation of health problems', there is no need for snow sports-specific recommendations. However, as the authors of the IOC statement encouraged, injury/illness surveillance should discontinue using *acute* and *overuse* as a simple dichotomy and implement a more nuanced classification system that describes both injury/illness presentation (*sudden* or *gradual onset*) and the underlying mechanisms (*acute* or *repetitive*). In this context, classification examples for the 'mode of onset' in different snow sports disciplines are provided in table 2.

For the classification of health problems, snow sports-specific standard descriptors for the occurrence of injury (ie, the events/factors leading to the injury situation, the injury situation itself and the injury mechanisms) are suggested in table 3. These suggestions represent a 'best practice' compilation of factors that, in an 'ideal scenario', could be recorded and reported by any injury/illness surveillance system in the snow sports context. Athletes' self-reported and staff-collected data should be captured separately and combined to maximise data quality. In addition, if epidemiological data are primarily collected for aetiological analyses of injury mechanisms, we recommend that all available complementary data, such as video recordings, wearable sensor data and/or athletes' or coaches' statements on the injury, be compiled and stored, as they contain valuable supplementary information for possible post hoc analysis by experts. In cases where resources are limited (eg, in youth or recreational settings), it should at least be indicated whether the mechanism of injury is classified as *direct contact*, *indirect contact* or *non-contact*, as suggested in the IOC statement.[13 14]

Classifying sports injury and illness diagnoses

As a minimum standard, we recommend classifying injuries by body area and (if reported by medical staff) tissue type and

Table 3 Snow sports discipline-specific descriptors for injury occurrence

Snow sports discipline	Events/factors leading to the injury situation	Injury situation	Injury mechanism
Alpine skiing/snowboarding; ski/snowboard cross	**Assumed initial trigger** ► Technical or tactical mistakes ► Changing/specific snow conditions ► Equipment behaviour or failure ► Course/jump difficulties ► Changing/poor weather, wind or visibility ► High skiing/riding speeds ► Athlete fatigue/overloading ► Impaired performance ► Influence of another skier/rider (in a parallel event, a ski/boarder cross or on public slopes) ► Other	**General accident data** ► Date/place ► Environmental conditions (weather/wind temperature/altitude/visibility/snow conditions) ► Off-snow or on-snow ► Training or competition ► Qualification or finals (for cross disciplines only) ► Subdiscipline ► Terrain (flat, medium, steep and transition) ► Course set (gate distance trap, small offset, medium offset, wide offset, transition in course sets, combinations—for slalom only) ► Course section (1/4; 2/4; 3/4; 4/4) ► Course feature (for cross-disciplines only) ► Number of consecutive days of on-snow/off-snow activity ► Number of runs on the same day **Skiing/riding situation** ► Turning (for snowboard only: toe/heel side) ► Jumping (take-off, landing) ► Straight skiing/riding ► Other **Skier/rider behaviour** (*before injury, at injury time, after injury*) ► In balance ► Off balance ► Falling (forwards, backwards, left, right) ► Crashing ► Other **Appropriate binding/airbag release** (*if applicable*) ► Yes ► No ► N/a **Helmet/protector use** (*especially in the recreational setting*) ► Yes ► No ► N/a	**Direct contact** ► During impacts on a snow surface ► During gate/obstacle/feature contact ► During security net/material contact ► During a collision with another skier/rider (in a parallel event, a ski/boarder cross or on public slopes) ► Other **Indirect contact** ► After impact on a snow surface ► After gate/obstacle contact ► After security net/material contact ► After a collision with another skier/rider (in a parallel event, a ski/boarder cross or on public slopes) ► Other **Non-contact** ► Yes ► No ► N/a

Continued

Table 3 Continued

Snow sports discipline	Events/factors leading to the injury situation	Injury situation	Injury mechanism
Freestyle skiing/ snowboarding	**Assumed initial trigger** ► Technical or tactical mistakes ► Changing/specific snow conditions ► Equipment behaviour or failure ► Course/jump difficulties ► Changing/poor weather, wind or visibility ► High skiing/riding speeds ► Athlete fatigue/overloading ► Impaired performance ► Other	**General accident data** ► Date/place ► Environmental conditions (weather/ wind temperature/altitude/visibility/snow conditions) ► Off-snow (gym, trampoline, water ramps, airbag and skate park) *or* on-snow (halfpipe, park, aerials, moguls and free riding) ► Training or competition ► Subdiscipline ► Terrain (flat, medium, steep and transition) ► Course section/feature: – Halfpipe: top/bottom, wall/flat – Slopestyle: top/bottom, course feature – Moguls: top/bottom, jump1/jump2 – Aerials/big air: approach/landing ► Trick difficulty (eg, single/double/triple spins or rotations, depending on the subdiscipline terminology) ► Number of consecutive days of on-snow/ off-snow activity ► Number of runs on the same day **Skiing/riding situation** ► Turning ► Jumping (take-off, landing) ► Straight skiing/riding ► Back seat/switch ► Other **Skier/rider behaviour** (*before injury, at injury time, after injury*) ► In-balance ► Off-balance ► Falling (forwards, backwards, left and right) ► Crashing ► Other **Appropriate binding/airbag release** (*if applicable*) ► Yes ► No ► N/a **Helmet/protector use** (*especially in the recreational setting*) ► Yes ► No ► N/a	**Direct contact** ► During impacts on a snow surface ► During obstacle/element contact ► During security net/material contact ► Other **Indirect contact** ► After impact on a snow surface ► After obstacle/element contact ► After security net/material contact ► Other **Non-contact** ► Yes ► No ► N/a
Cross-country skiing	**Assumed initial trigger** ► Technical or tactical mistakes ► Changing/specific snow/track conditions ► Equipment behaviour or failure ► Track difficulty/course profile ► Changing/poor weather, wind or visibility ► High skiing speeds ► Athlete fatigue/overloading ► Impaired performance ► Influence of another skier ► Other	**General accident data** ► Date/place ► Environmental conditions (weather/ wind temperature/altitude/visibility/snow conditions) ► Off-snow *or* on-snow ► Training or competition Technique (freestyle, classic) and subtechnique (ie, gear) ► Competition format (sprint/distance, individual/mass) ► Qualification/heats (for sprint competitions only) **Skiing situation** ► Start ► Flat ► Climb ► Descent ► Turn ► Finish ► Other	**Direct contact** ► During impacts on a snow surface ► During obstacle contact ► During contact with another competitor or a third person ► During contact with a ski/pole (own or other) ► Other **Indirect contact** ► After impact on a snow surface ► After obstacle contact ► After contact with another person ► After contact with a ski/pole (own or other) ► Other **Non-contact** ► Yes ► No ► N/a

Continued

Table 3 Continued

Snow sports discipline	Events/factors leading to the injury situation	Injury situation	Injury mechanism
Ski jumping	**Assumed initial trigger** ► Technical or tactical mistakes ► Changing/specific snow conditions ► Equipment behaviour or failure ► Ski jumping hill difficulty/profile ► Changing/poor weather, wind or visibility ► Landing impact ► Telemark landing in an unfavourable situation ► Athlete fatigue/overloading ► Impaired performance ► Other	**General accident data** ► Date/place ► Environmental conditions (weather/wind temperature/altitude/visibility/snow conditions) ► Off-snow or on-snow/plastic ► Training or competition ► Qualification or finals ► Hill size classification/jump length ► Telemark landing (yes, no); front knee (left, right) ► Number of jumps on the same day **Skiing situation** ► Inrun/outrun ► Take-off ► Air phase ► Landing **Skier behaviour** (*before injury, at injury time, after injury*) ► In balance ► Off balance ► Falling (forwards, backwards, left and right) **Appropriate binding release** (*if applicable*) ► Yes ► No ► N/a	**Direct contact** ► During impacts on a snow surface ► During security wall contact ► Other **Indirect contact** ► After impact on a snow surface ► After security wall contact ► Other **Non-contact** ► Yes ► No ► N/a

pathology type. As a minimum standard for classifying illnesses, we recommend noting the symptoms (if reported by medical staff) of the related organ system/region and aetiology, as further explained in the IOC statement.[13 14] Where possible, injury and illness diagnoses should be classified using the Orchard Sports Injury and Illness Classification System (OSIICS) or the Sports Medicine Diagnostic Coding System (SMDCS). In cases where these systems do not provide specific enough diagnoses, for example, if an alpine skier suffers a *medial talar process avulsion* due to torsion in the boot, the closest possible code should be used (eg, OSIICS code: AF2; SMDCS code: AN.30.13; fractured talus), with the medical staff also recording the exact diagnosis separately.

Further examples of snow sports-specific injuries and illnesses with no specific code being directly available (mainly due to different pathophysiologies) include *atypical Scheuermann's disease* (DG1; TS.31.20; Scheuermann's disease); *Schmorl's nodes* (LCP/DC1; LS.42.33/TS.52.33; lumbar/thoracic disc prolapse); *endplate changes* (LGJ/DLJ; n/a; lumbar/thoracic spine joint injury); *distal femoral cortical irregularities* (TZS, n/a; other stress/overuse injuries to the thigh); *boot-induced lower leg contusion* (QVT; LE.60.24; pretibial periosteal bruising/haematoma); *boot-induced pretibial/medial tibial stress syndromes* (QTT/QT1; LE.32.42; anterior shin splints/medial tibial stress syndrome); *exercise-induced anterior compartment syndromes* (QY2; LE.30.13; acute anterior compartment syndrome) and exercise-induced asthma/bronchoconstriction in subzero temperatures (MPEE; RE.0174; exercise-induced asthma).

The severity of health problems

To quantify the severity of health problems, the IOC statement[13 14] suggests (1) the use of *time loss* (defined as the 'number of days that the athlete is not fully available for training and competition, from the self-reported date of onset until the athlete is fully available for training or competition') or (2) the athlete's *self-reported consequences*, such as the cumulative severity score that can be calculated based on the OSTRC-H2 questionnaire.[73] The latter option (2) is preferable when injuries and illnesses are surveyed based on athlete-reported data.[13 14 73] Both approaches and all other severity measures mentioned in the IOC statement (ie, clinical outcomes, functional measures, performance measures and patient-reported outcome measures) are also appropriate for injury/illness severity descriptions in snow sports.

Regarding the severity classification by time loss, a major challenge in various snow sports disciplines is identifying when an injured/ill athlete is 'fully' recovered and when the time loss ends. Rehabilitation is a gradual process, and different stages of the continuum can be considered fully recovered (eg, 'return-to-participation', 'return-to-sport' and/or 'return-to-competition', as described by Ardern *et al*).[74] In this regard, we support the IOC statement that the 'number of time-loss days should be counted from the day after the onset that the athlete cannot participate (day 1) through the day before the athlete is fully available for training or competition'.[13 14] Nevertheless, such a return may be premature or only partial. For example, a snow sports athlete may fully participate in off-snow training but decide not to train on snow for the moment, as performing the sport in unpredictable and changing snow conditions is not as controllable as training in the gym or on constantly hard surfaces. Another example would be a not-fully-recovered snow sports athlete who accepts an increased risk by returning early to an important event, such as World Championships or Olympic Games but skips the rest of the season or only participates in certain subdisciplines or activities. Given the specific characteristics of snow sports, which often involve high speeds and/or forces, this decision-making process will likely differ from many other Olympic sports, where the risk of reinjury is much lower. We, therefore, agree with the circus-specific extension of the IOC statement[18] and recommend a slightly more nuanced method of categorising time loss as *full*, *partial* or *no* time loss.

Examples of such classifications from the snow sports context are presented in table 4. Another more sophisticated solution might be to use the prospective OSTRC-H2 method, which overcomes this issue by capturing severity through a graded scale.

Table 4 Snow sports-specific examples for classifications with time loss

Full-time loss (days)	Partial time loss (days)	Influence (days)	Example
0	0	12	During a big air competition, a snowboarder falls while landing and feels pain in the wrist. Nevertheless, the athlete continues to compete.
0	0	26	An alpine skier suffers from gradually increasing back pain during an intensive strength training session but completes the session. Over the next few days, the athlete performs strength training again, however, now on controlled weight training equipment instead of with free weights.
7	14	21	During a telemark landing, a ski jumper suffers an unfavourable joint strain in the right knee. During the following week, the athlete does not train at all. The next week, training gradually begins but any jumping activities are avoided for two further weeks.
0	4	4	During summer training, a mogul skier suffers from hip pain after landing awkwardly during a jump. The next day the athlete continues on-snow training on the glacier but does not perform any jumps between the moguls. Intense conditioning training is avoided on days 3 and 4, before fully returning to team training on day 5.
3	3	6	A cross-country skier has a cold. No training is possible for the first 3 days and only limited, low-intensity training is possible for the following 3 days.

Capturing and reporting athlete exposure

Capturing and reporting exposure is fundamental for expressing injury and illness risk; however, the choice of exposure measures is strongly influenced by discipline and contextual factors as well as the types of health problems of interest.[13 14] We advocate the following approaches to harmonise exposure reporting in snow sports.

Minimum standard of capturing and reporting exposure across different snow sports disciplines and application contexts for injury analyses

To allow the comparison of injury and illness rates across different snow sports disciplines and application contexts, we recommend using the gross exposure estimate *per 100 athletes per season* as a minimum capture and reporting standard. One season refers to 1 year/12 months/365 days. Such an approach may be better suited to the differing nature of exposure in various snow sports disciplines. In addition, it accounts for the substantial methodological challenges of quantifying exposure in its diversity and may allow a comparison of the risks between different sports and snow sports disciplines. Finally, we consider per 100 athletes to be more intuitive than per 1000 athletes for communicating risks across relevant snow sport stakeholders (eg, officials, team staff, parents and athletes), as they are more likely to be familiar with this percentage.

More detailed exposure measures

Depending on the purpose of the surveillance, more detailed exposure measures may be indicated, provided that the exposure can be determined exactly. In this regard, we suggest recording and reporting exposure (and thus injury rates) separately by activity type and subcontent. This may include a more nuanced distinction between the activity types of *off-snow training* (including warm-up, physical conditioning, imitation exercises without skis or board and performance tests), *on-snow training* (representing training activities in the athletes' main sports disciplines, including warm-up and main training activities) and *competition* (official competitive events including qualification runs). If off-snow training is monitored, this activity type can further be divided into its subcontent *endurance*, *strength*, *skill and speed*, *agility* and *complementary training* (eg, quality of movement, recovery and participation in different sports). A compilation of recommended exposure measures in relation to specific snow sports disciplines, types of activity and special application contexts are outlined in table 5 and described in the subsequent paragraphs.

Discipline-specific recommendations for capturing and reporting exposure for the purpose of injury analyses

For technical disciplines (eg, alpine skiing, freestyle skiing and snowboarding), expressing exposure by the more detailed measures *per 1000 runs* (on-snow training/competition) or *per 100 training units* (off-snow training) is recommended. For more advanced levels, *per 1000 turns/elements* (on-snow training/competition) may also be captured and reported.

For cross-country skiing, we recommend expressing exposure through more detailed measures *per 1000 hours skiing* (on-snow training/competition) or *per 1000 hours training* (off-snow training). For more advanced levels, *per 1000 km skiing* (on-snow training/competition) may also be captured and reported. Due to the strong similarity of roller skiing to on-snow skiing, roller skiing is considered 'on-snow training' and is recommended to be classified in this category.

For ski jumping, more detailed exposure measures *per 1000 jumps* (on-snow training/competition training) or *per 100 training units* (off-snow training) are recommended. Due to the strong similarity between summer ski jumping and winter ski jumping, summer ski jumping is considered 'on-snow training/competition' and is recommended for classification in this category.

Capturing and reporting exposure for illness analyses

As athletes remain at risk of developing illnesses even when not participating in sports, illnesses should not be expressed per training or competition exposure, but rather *per time athletes are under surveillance* (eg, days, weeks, months or years).[13 14]

Special case: capturing and reporting exposure at multiday events in snow sports

As a minimum standard, we recommend expressing exposure *per 100 athletes*. If feasible, the actual days of the individual athletes participating in the event should be considered and reported as *per 365 athlete days*.[13 14]

Table 5 Recommendations for the specific use of exposure measures in relation to different snow sports disciplines, activity types and special application contexts

Discipline	Activity type	Special application context
All disciplines	*Per 100 athletes per season**	
Alpine skiing/snowboarding; ski/snowboard cross	**Off-snow training** *Per 100 training units*†‡ **On-snow training/competition** *Per 1000 runs*‡ *Per 1000 turns*‡	**Sports event** *Per 100 athletes* *Per 365 athlete-days* **Ski resorts**§ *Per 1000 person-days*
Freestyle skiing/snowboarding	**Off-snow training** *Per 100 training units*†‡ **On-snow training/competitions** *Per 1000 runs*‡ *Per 1000 elements*‡	**Sports event** *Per 100 athletes* *Per 365 athlete-days* **Ski resorts**§ *Per 1000 person-days*
Cross-country skiing	**Off-snow training** *Per 1000 hours training*‡ *(eg, running or cycling)* **On-snow training/competitions** *Per 1000 hours skiing*‡ *(eg, on-snow skiing and roller skiing)* *Per 1000 km skiing*‡ *(eg, on-snow skiing and roller skiing)*	**Sports event** *Per 100 athletes* *Per 365 athlete-days*
Ski jumping	**Off-snow training** *Per 100 training units*†‡ **On-snow training/competitions** *Per 1000 jumps*‡ *(eg, summer and winter ski jumping)*	**Sports event** *Per 100 athletes* *Per 365 athlete-days*

*One season refers to 1 year=12 months=365 days.
†Training unit = continuous training block comprising at least 30 min of activity.
‡To be separated by subcontent.
§Only differentiable by equipment (alpine skis, touring skis or snowboards) and place of accident (slope, slope intersection, terrain/fun park, lift, etc), as typically registered by the lift tickets sold and further specified by the injury report of the ski patrollers.

Special case: capturing and reporting exposure in the recreational snow sports context

In recreational snow sports, we recommend continuing the traditional approach, that is, capturing and reporting exposure *per 1000 person-days*. For comparisons between recreational and competitive sports, *per 1000 person-days* can be easily converted to *per 365 athlete days* to align with the IOC statement.[13 14]

Reporting measures of occurrence

The IOC statement[13 14] recommendations largely apply to the context of snow sports when reporting measures of occurrence. As such, *prevalence* is calculated based on the number of athletes with a health problem at a given time (point prevalence) or a window of time (period prevalence), while *incidence* refers to the number of new health problems during a defined time period.[13 14] Incidence-based measures are considered more appropriate for sudden-onset health problems, whereas prevalence-based measures are more appropriate for gradual-onset health problems.[13 14]

As a minimum standard, we recommend expressing injury/illness rates as *the number of new injuries or illnesses per 100 athletes per season*, as the preferred directly comparable measure of incidence across different snow sports disciplines and contexts of application. For gradual-onset health problems, the period prevalence is reported as *the number of injured or ill athletes per 100 athletes per season*. One season refers to 1 year/12 months/365 days. Depending on the purpose of the surveillance, more sophisticated exposure denominators may be indicated for specific injury (but not illness) surveillance purposes. A summary of the recommended alternative exposure denominators in relation to specific snow sports disciplines, types of activity and specific application contexts is shown in table 5. When using the OSTRC-H2 questionnaire, we recommend reporting its standard outcome measures, such as the *average weekly prevalence*.[73] Additionally, we encourage reporting injury/illness rates separately for the international *competition season period* (from approximately November to April) and *preseason period* (from approximately May to October). The exact dates vary slightly between different snow sports disciplines and levels.

The burden of health problems

In snow sports disciplines such as alpine skiing, freestyle skiing and snowboarding, the rates of severe injuries are relatively high compared with those in other Olympic sports.[69 75] In the Beijing 2022 Winter Olympics, for instance, 13 of the 20 joint sprains/ligament tears occurred in Olympic disciplines governed by FIS.[69] Consequently, the financial costs of surgeries and extensive rehabilitation and the overall physical, psychological and socioeconomic burdens on snow sports athletes are high. Therefore, we encourage NSSAs to systematically record and report injury and illness burden (defined as the cross-product of incidence and severity) along with the associated costs. For all further aspects regarding the burden of problems, readers are referred to the IOC statement.[13 14] In relation to this, we acknowledge that the burden of injury is a latent construct with multilayered implications that depend on various contextual factors, and that these contextual factors extend beyond financial aspects. However, while also relevant to the context of snow sports, we have not explicitly discussed these factors (eg, psychosocial characteristics or long-term health consequences) as they do not differ from those originally described in the IOC statement.

Table 6 Patterns of 266 injuries distributed among 82 Norwegian Olympic athletes between 2011 and 2020, presented by body region and tissue type

Region	Injuries	Incidence	Median time loss	Burden
Tissue type	N	Injuries per 100 athlete seasons (95% CI)	Days (25th, 75th percentile)	Time loss days per 100 athlete seasons (95% CI)
OSIICS-13 diagnosis				
Head	**11**	**11.61 (6.16, 20.1)**	**2 (1, 6)**	**66.50 (51.56, 84.5)**
Nervous	5	5.28 (2, 11.57)	4 (2, 7)	50.67 (37.81, 66.58)
Concussion	*5*	*5.28 (2, 11.57)*	*4 (2, 7)*	*50.67 (37.81, 66.58)*
Bone	1	1.06 (0.1, 4.92)	5 (5, 5)	5.28 (2, 11.57)
Superficial tissues/skin	1	1.06 (0.1, 4.92)	1 (1, 1)	1.06 (0.1, 4.92)
Vessels	2	2.11 (0.42, 6.77)	0 (0, 1)	1.06 (0.1, 4.92)
Non-specific	2	2.11 (0.42, 6.77)	4 (2, 6)	8.44 (3.98, 15.94)
Neck	**10**	**10.56 (5.42, 18.73)**	**0 (0, 1)**	**5.28 (2, 11.57)**
Muscle/tendon	3	3.17 (0.88, 8.45)	0 (0, 2)	3.17 (0.88, 8.45)
Cartilage/synovium/bursa	1	1.06 (0.1, 4.92)	0 (0, 0)	0.00 (0, 2.6)
Non-specific	6	6.33 (2.63, 13.06)	0 (0, 1)	2.11 (0.42, 6.77)
Shoulder	**13**	**13.72 (7.69, 22.8)**	**0 (0, 1)**	**20.06 (12.48, 30.68)**
Muscle/tendon	5	5.28 (2, 11.57)	0 (0, 0)	1.06 (0.1, 4.92)
Bone	1	1.06 (0.1, 4.92)	4 (4, 4)	4.22 (1.41, 10.04)
Cartilage/synovium/bursa	2	2.11 (0.42, 6.77)	0 (0, 0)	0.00 (0, 2.6)
Ligament/joint capsule	1	1.06 (0.1, 4.92)	13 (13, 13)	13.72 (7.69, 22.8)
Non-specific	4	4.22 (1.41, 10.04)	0 (0, 0)	1.06 (0.1, 4.92)
Elbow	**5**	**5.28 (2, 11.57)**	**0 (0, 1)**	**3.17 (0.88, 8.45)**
Muscle/tendon	1	1.06 (0.1, 4.92)	0 (0, 0)	0.00 (0, 2.6)
Ligament/joint capsule	3	3.17 (0.88, 8.45)	1 (0, 2)	3.17 (0.88, 8.45)
Non-specific	1	1.06 0.1, 4.92)	0 (0, 0)	0.00 (0, 2.6)
Forearm	**2**	**2.11 (0.42, 6.77)**	**0 (0, 0)**	**0.00 (0, 2.6)**
Muscle/tendon	1	1.06 (0.1, 4.92)	0 (0, 0)	0.00 (0, 2.6)
Non-specific	1	1.06 (0.1, 4.92)	0 (0, 0)	0.00 (0, 2.6)
Wrist	**7**	**7.39 (3.3, 14.51)**	**0 (0, 0)**	**13.72 (7.69, 22.8)**
Muscle/tendon	2	2.11 (0.42, 6.77)	6 (3, 9)	12.67 (6.92, 21.45)
Vessels	1	1.06 (0.1, 4.92)	0 (0, 0)	0.00 (0, 2.6)
Non-specific	4	4.22 (1.41, 10.04)	0 (0, 0)	1.06 (0.1, 4.92)
Hand	**4**	**4.22 (1.41, 10.04)**	**2 (2, 4)**	**13.72 (7.69, 22.8)**
Ligament/joint capsule	3	3.17 (0.88, 8.45)	2 (2, 5)	11.61 (6.16, 20.1)
Non-specific	1	1.06 (0.1, 4.92)	2 (2, 2)	2.11 (0.42, 6.77)
Chest	**7**	**7.39 (3.3, 14.51)**	**1 (1, 8)**	**32.72 (22.67, 45.83)**
Muscle/tendon	3	3.17 (0.88, 8.45)	6 (4, 10)	21.11 (13.3, 31.97)
Bone	2	2.11 (0.42, 6.77)	0 (0, 1)	1.06 (0.1, 4.92)
Cartilage/synovium/bursa	1	1.06 (0.1, 4.92)	1 (1, 1)	1.06 (0.1, 4.92)
Internal organs	1	1.06 (0.1, 4.92)	9 (9, 9)	9.50 (4.69, 17.34)
Thoracic spine	**3**	**3.17 (0.88, 8.45)**	**0 (0, 2)**	**4.22 (1.41, 10.04)**
Muscle/tendon	2	2.11 (0.42, 6.77)	0 (0, 0)	0.00 (0, 2.6)
Non-specific	1	1.06 (0.1, 4.92)	4 (4, 4)	4.22 (1.41, 10.04)
Lumbosacral	**30**	**31.67 (21.8, 44.59)**	**0 (0, 2)**	**54.89 (41.45, 71.39)**
Muscle/tendon	3	3.17 (0.88, 8.45)	0 (0, 9)	19.00 (11.66, 29.38)
Bone	1	1.06 (0.1, 4.92)	0 (0, 0)	0.00 (0, 2.6)
Cartilage/synovium/bursa	1	1.06 (0.1, 4.92)	0 (0, 0)	0.00 (0, 2.6)
Ligament/joint capsule	1	1.06 (0.1, 4.92)	3 (3, 3)	3.17 (0.88, 8.45)
Non-specific	24	25.33 (16.65, 37.07)	0 (0, 1)	32.72 (22.67, 45.83)
Abdomen	**5**	**5.28 (2, 11.57)**	**1 (1, 2)**	**7.39 (3.3, 14.51)**
Muscle/tendon	1	1.06 (0.1, 4.92)	1 (1, 1)	1.06 (0.1, 4.92)
Internal organs	1	1.06 (0.1, 4.92)	1 (1, 1)	1.06 (0.1, 4.92)
Non-specific	3	3.17 (0.88, 8.45)	2 (1, 2)	5.28 (2, 11.57)
Hip/groin	**25**	**26.39 (17.5, 38.33)**	**0 (0, 2)**	**82.34 (65.55, 102.18)**
Muscle/tendon	9	9.50 (4.69, 17.34)	0 (0, 2)	11.61 (6.16, 20.1)
Bone	1	1.06 (0.1, 4.92)	50 (50, 50)	52.78 (39.63, 68.99)
Ligament/joint capsule	3	3.17 (0.88, 8.45)	0 (0, 0)	0.00 (0, 2.6)

Continued

Table 6 Continued

Region	Injuries	Incidence	Median time loss	Burden
Non-specific	12	12.67 (6.92, 21.45)	0 (0, 1)	17.95 (10.85, 28.08)
Thigh	**13**	**13.72 (7.69, 22.8)**	**1 (0, 2)**	**22.17 (14.13, 33.25)**
Muscle/tendon	9	9.50 (4.69, 17.34)	1 (0, 1)	17.95 (10.85, 28.08)
Non-specific	4	4.22 (1.41, 10.04)	1 (0, 2)	4.22 (1.41, 10.04)
Knee	**66**	**69.67 (54.35, 88.05)**	**1 (0, 7)**	**2494.44 (2395.38, 2596.55)**
Muscle/tendon	9	9.50 (4.69, 17.34)	1 (0, 2)	14.78 (8.46, 24.13)
Patellar tendinopathy	*6*	*6.33 (2.63, 13.06)*	*2 (0, 3)*	*13.72 (7.69, 22.8)*
Bone	1	1.06 (0.1, 4.92)	3 (3, 3)	3.17 (0.88, 8.45)
Cartilage/synovium/bursa	19	20.06 (12.48, 30.68)	0 (0, 2)	46.45 (34.2, 61.75)
Patellofemoral joint chondral pain	*12*	*12.67 (6.92, 21.45)*	*0 (0, 1)*	*13.72 (7.69, 22.8)*
Ligament/joint capsule	20	21.11 (13.3, 31.97)	32 (2, 266)	2398.38 (2301.28, 2498.53)
ACL rupture	*8*	*8.44 (3.98, 15.94)*	*266 (266, 266)*	*2246.37 (2152.44, 2343.34)*
Grade 1 MCL tear knee	*5*	*5.28 (2, 11.57)*	*2 (0, 13)*	*49.61 (36.9, 65.38)*
Vessels	2	2.11 (0.42, 6.77)	0 (0, 1)	1.06 (0.1, 4.92)
Non-specific	15	15.83 (9.25, 25.46)	0 (0, 2)	30.61 (20.93, 43.34)
Lower leg	**22**	**23.22 (14.97, 34.53)**	**1 (0, 3)**	**200.57 (173.55, 230.64)**
Muscle/tendon	17	17.95 (10.85, 28.08)	1 (0, 3)	45.39 (33.3, 60.54)
Tenoperiostitis of lower leg	*5*	*5.28 (2, 11.57)*	*3 (1, 4)*	*22.17 (14.13, 33.25)*
Bone	1	1.06 (0.1, 4.92)	144 (144, 144)	152.01 (128.68, 178.39)
Non-specific	4	4.22 (1.41, 10.04)	0 (0, 1)	3.17 (0.88, 8.45)
Ankle	**20**	**21.11 (13.3, 31.97)**	**1 (0, 3)**	**109.78 (90.18, 132.45)**
Muscle/tendon	1	1.06 (0.1, 4.92)	3 (3, 3)	3.17 (0.88, 8.45)
Cartilage/synovium/bursa	2	2.11 (0.42, 6.77)	30 (16, 43)	62.28 (47.87, 79.75)
Ligament/joint capsule	6	6.33 (2.63, 13.06)	0 (0, 7)	32.72 (22.67, 45.83)
Vessels	4	4.22 (1.41, 10.04)	2 (1, 3)	7.39 (3.3, 14.51)
Non-specific	7	7.39 (3.3, 14.51)	0 (0, 1)	4.22 (1.41, 10.04)
Foot	**23**	**24.28 (15.81, 35.8)**	**1 (0, 4)**	**72.84 (57.14, 91.59)**
Muscle/tendon	1	1.06 (0.1, 4.92)	2 (2, 2)	2.11 (0.42, 6.77)
Nervous	1	1.06 (0.1, 4.92)	0 (0, 0)	0.00 (0, 2.6)
Bone	2	2.11 (0.42, 6.77)	16 (9, 24)	34.84 (24.41, 48.31)
Ligament/joint capsule	3	3.17 (0.88, 8.45)	2 (1, 2)	5.28 (2, 11.57)
Superficial tissues/skin	1	1.06 (0.1, 4.92)	0 (0, 0)	0.00 (0, 2.6)
Vessels	2	2.11 (0.42, 6.77)	2 (2, 3)	5.28 (2, 11.57)
Non-specific	13	13.72 (7.69, 22.8)	0 (0, 4)	25.33 (16.65, 37.07)
Region unspecified	**1**	**1.06 (0.1, 4.92)**	**0 (0, 0)**	**0.00 (0, 2.6)**
Muscle/tendon	1	1.06 (0.1, 4.92)	0 (0, 0)	0.00 (0, 2.6)

Specific OSIICS-13 diagnoses are presented if five or more of the same diagnoses were recorded. The underlying data originated from the Norwegian NOC database and were provided with kind permission for illustration in this study.
ACL, anterior cruciate ligament; MCL, medial collateral ligament; NOC, National Olympic Committee; OSIICS, Orchard Sports Injury and Illness Classification System.

Study population characteristics

Regarding the characteristics of the study population, the IOC recommends reporting, at minimum, the athlete's age, sex and performance level.[13 14] The authors of the statement also encourage sport-specific consensus groups to define what constitutes 'elite', 'subelite' and 'recreational' athletes in their respective contexts.[13 14] We suggest that study population characteristics are described primarily by the existing classification framework outlined by McKay *et al*[76] (tier 0: sedentary; tier 1: recreationally active; tier 2: trained/developmental; tier 3: highly trained/national level; tier 4: elite/international level and tier 5: world-class). However, in addition to this classification framework information, we recommend also reporting the athletes' (1) *world ranking positions* according to the FIS points or analogous systems and (2) the *type of competition* they most frequently participate (eg, in youth competitions; FIS competitions; Continental Cups, such as European, North American, South American, Asian, Australia/New Zealand; World Cup (WC); professional snow sports events not governed by FIS (eg, X Games); master competitions and mass participation sporting events).

Data collection methods

For the purpose of longitudinal injury/illness surveillance conducted in snow sports as part of national sports association initiatives (eg, by NSSAs or National Olympic Committees (NOCs)), we recommend combining athlete-reported and staff/physician-reported data as an ideal complementary approach. Data reported accurately by athletes are usually more sensitive (especially for less severe and gradual-onset injuries) but less specific (because medically informed diagnoses are usually lacking). In contrast, collecting injury/illness data by team staff/medical personnel may increase data specificity and help verify

Table 7 Patterns of 309 illnesses distributed among 80 Norwegian Olympic athletes between 2011 and 2020, presented by organ system and aetiology

Organ system	Illnesses	Incidence	Median time loss	Burden
Aetiology	N	Illnesses per 100 athlete seasons (95% CI)	Days (25th, 75th percentile)	Time loss days per 100 athlete seasons (95% CI)
OSIICS-13 diagnosis				
Cardiovascular	**2**	**2.11 (0.42, 6.77)**	**2 (1, 2)**	**3.17 (0.88, 8.45)**
Thrombotic/haemorrhagic	1	1.06 (0.1, 4.92)	3 (3, 3)	3.17 (0.88, 8.45)
Unknown or not specified	1	1.06 (0.1, 4.92)	0 (0, 0)	0.00 (0, 2.6)
Dermatological	**2**	**2.11 (0.42, 6.77)**	**0 (0, 0)**	**0.00 (0, 2.6)**
Immunological/inflammatory	1	1.06 (0.1, 4.92)	0 (0, 0)	0.00 (0, 2.6)
Infection	1	1.06 (0.1, 4.92)	0 (0, 0)	0.00 (0, 2.6)
Endocrinological	**6**	**6.33 (2.63, 13.06)**	**1 (0, 4)**	**87.62 (70.26, 108.03)**
Immunological/inflammatory	6	6.33 (2.63, 13.06)	1 (0, 4)	87.62 (70.26, 108.03)
Chronic fatigue syndrome	*5*	*5.28 (2, 11.57)*	*1 (0, 5)*	*86.56 (69.31, 106.86)*
Gastrointestinal	**30**	**31.67 (21.8, 44.59)**	**2 (0, 4)**	**71.78 (56.2, 90.41)**
Immunological/inflammatory	1	1.06 (0.1, 4.92)	7 (7, 7)	7.39 (3.3, 14.51)
Infection	16	16.89 (10.05, 26.77)	2 (1, 5)	50.67 (37.81, 66.58)
Gastrointestinal infection	*16*	*16.89 (10.05, 26.77)*	*2 (1, 5)*	*50.67 (37.81, 66.58)*
Multiple	13	13.72 (7.69, 22.8)	1 (0, 2)	13.72 (7.69, 22.8)
Gastrointestinal illness	*11*	*11.61 (6.16, 20.1)*	*2 (0, 2)*	*12.67 (6.92, 21.45)*
Neurological	**9**	**9.50 (4.69, 17.34)**	**1 (1, 1)**	**8.44 (3.98, 15.94)**
Immunological/inflammatory	2	2.11 (0.42, 6.77)	0 (0, 1)	1.06 (0.1, 4.92)
Unknown or not specified	7	7.39 (3.3, 14.51)	1 (1, 1)	7.39 (3.3, 14.51)
Psychiatric/psychological	**3**	**3.17 (0.88, 8.45)**	**2 (2, 3)**	**7.39 (3.3, 14.51)**
Multiple	3	3.17 (0.88, 8.45)	2 (2, 3)	7.39 (3.3, 14.51)
Respiratory	**231**	**243.85 (213.91, 276.85)**	**2 (0, 4)**	**745.27 (691.81, 801.78)**
Allergic	2	2.11 (0.42, 6.77)	2 (2, 2)	4.22 (1.41, 10.04)
Infection	227	239.63 (209.96, 272.35)	2 (0, 4)	735.77 (682.66, 791.93)
Respiratory infection	*227*	*239.63 (209.96, 272.35)*	*2 (0, 4)*	*735.77 (682.66, 791.93)*
Unknown or not specified	2	2.11 (0.42, 6.77)	2 (2, 3)	5.28 (2, 11.57)
Multiple systems	**16**	**16.89 (10.05, 26.77)**	**0 (0, 0)**	**15.83 (9.25, 25.46)**
Infection	9	9.50 (4.69, 17.34)	0 (0, 3)	14.78 (8.46, 24.13)
Infection, other	*5*	*5.28 (2, 11.57)*	*0 (0, 0)*	*7.39 (3.3, 14.51)*
Metabolic/nutritional	7	7.39 (3.3, 14.51)	0 (0, 0)	1.06 (0.1, 4.92)
Tired athlete undiagnosed	*5*	*5.28 (2, 11.57)*	*0 (0, 0)*	*1.06 (0.1, 4.92)*
Unknown or not specified	**5**	**5.28 (2, 11.57)**	**1 (0, 3)**	**12.67 (6.92, 21.45)**
Multiple	5	5.28 (2, 11.57)	1 (0, 3)	12.67 (6.92, 21.45)
Medical illness undiagnosed/ other	*5*	*5.28 (2, 11.57)*	*1 (0, 3)*	*12.67 (6.92, 21.45)*

Specific OSIICS-13 diagnoses are presented if five or more of the same diagnoses were recorded. The underlying data originated from the Norwegian NOC database and were provided with kind permission for illustration in this study.
NOC, National Olympic Committee; OSIICS, Orchard Sports Injury and Illness Classification System.

and correct incomplete/incorrect information provided by athletes. However, early-stage health problems may go undetected unless medical treatment is actively sought by the athlete. Electronic data capture tools, real-time data processing solutions and instant feedback/query capabilities may improve response rates and practical usability. In this context, for example, validated standard methods for prospective injury/illness surveillance, such as the OSTRC-H2 questionnaire, could be implemented in web-based platforms and combined with continuously updated team medical records and a supplementary retrospective interview at the end of an observation period to verify the accuracy and completeness of all OSTRC-H2-based entries, as has been done in previous studies.[47 77]

For the purpose of longitudinal injury/illness surveillance conducted in snow sports as part of international sports association initiatives, a previous study revealed that retrospective interviews with FIS WC athletes/coaches regarding injuries during the previous 6 months provided the most complete picture of injuries incurred by skiers and snowboarders.[78] This approach was reported to be superior to alternative methods, such as prospective injury reports by FIS technical delegates or prospective medical team registration by selected teams. An alternative and promising approach that FIS is currently used in alpine skiing is to exploit data from injury status applications to capture as much detailed information on injury/illness occurrence and causation as possible. A limitation of such an approach is, however, that only injuries/illnesses with substantial time loss are reported, while less severe health problems are neglected. Thus, complementary injury/illness surveillance initiatives by national bodies such as NSSAs and NOCs following the recommendations of the present statement are essential.

For injury and illness surveillance during multiday events, dedicated injury and illness registration forms completed by the medical staff responsible for the event are considered most

appropriate. An example of a snow sports-related study using such methodology is the study of Kastner and colleagues which investigated the injuries and illnesses occurring during the 53rd FIS Nordic World Ski Championships in Oberstdorf.[64]

The newest versions of injury and illness surveillance approaches emphasise monitoring mental health in addition to physical health. For more detailed information on corresponding minimum standards, please refer to the mental health supplement to the IOC statement[21] and its supplemental material 1–3 (https://bjsm.bmj.com/content/57/21/1351#supplementary-materials), where (1) an athlete's weekly questionnaire for monitoring physical and mental health problems (for longitudinal use based on athlete reporting), (2) a medical report for injury, illness and mental health problems (for longitudinal use based on reporting by the medical staff) and (3) a daily medical report on injuries, illnesses and mental health problems (for event-related use based on reporting by the medical staff) can be accessed and downloaded.

For injury surveillance as part of the systematic registration routine in ski resorts, customised injury registration forms completed by the responsible medical staff of the ski resorts are standard. An example of such a form that is used by the slope rescue service in Sölden, Austria, can be found as an English-translated version in the online supplemental material file B.

Finally, regardless of the data collection methodology used, we strongly recommend that all injury and illness data be reported with reference to the STROBE Extension for Sport Injury and Illness Surveillance (STROBE-SIIS) checklist.[13 14] Table 6 and table 7 provide illustrative examples based on injury and illness data from the Norwegian NOC database, which have been provided with kind permission for illustration in this study and are reported in accordance with the recommendations of the IOC statement, the STROBE-SIIS and this snow sports-specific extension.

Regarding aspects of research ethics and data security, the recommendations of the IOC statement are also applicable to snow sports, whereby data should only be collected when pertinent to the specific surveillance/research question. Data protection and confidentiality must be assured, with access limited to only those individuals in the entourage identified through clear consent mechanisms. The collection of sensitive data should be conducted in an environment that is private, safe and respectful.

Specific considerations for injury and illness surveillance in youth snow sports athletes

Athletes should start developing a thorough understanding of their physical and mental health as early as possible, which would aid in meaningful injury and illness registration/management throughout their careers. In a qualitative study in which stakeholders from different Olympic sports were interviewed, athletes, in particular, emphasised the need for awareness and better education on injury prevention at their early career stages to facilitate their learning process and influence their future prevention behaviour and sporting success.[79] Moreover, in the context of snow sports, stakeholders explicitly acknowledge the value of knowledge and experience when managing and dealing with risks.[80] To this end, regular educational workshops for youth athletes, coaches and parents organised by regional or national federations are recommended. As stakeholders from the snow sports context suggested, young athletes, in particular, might benefit from educational interventions that focus on developing risk assessment and management skills.[80] However, whether such approaches effectively protect the health of young, aspiring snow sport athletes remains to be verified in future research.

For U12 athletes with a competitive focus, we recommend that coaches prospectively record all relevant injury and illness information in close cooperation with parents and, if possible, medical staff. From the U14 level upwards, young athletes should record their injuries/illnesses in parallel with their coaches, and the reports should be compared and consolidated approximately twice a year. Again, medical staff should be involved in recording routines wherever possible. At the U16 level, or when athletes acquire an appropriate degree of autonomy, validated standard methods such as the OSTRC-H2 questionnaire may be used. In such cases, a retrospective interview performed by a physician is recommended immediately after reporting, or at least at the end of the season, to clarify and verify all self-reported data.[42 50] Moreover, biological maturation and the load-sensitive phases of accelerated growth play a key role in the pathophysiology of various injuries and illnesses.[81–83] Thus, we suggest that epidemiological studies of youth-level athletes adopt indicators of biological maturation (such as age at peak height velocity and maturity offset as defined by Mirwald and colleagues)[84] and information on all sports activities performed.

Specific considerations for injury and illness surveillance in female snow sports athletes

Injury and illness surveillance of female snow sports athletes should include documentation of female-specific factors associated with health problems or consequences that could affect sports participation or performance. Moore *et al*[20] published a supplemental paper to the IOC statement identifying 10 female health domains (see tables 1–3 in their work). These domains also apply unrestrictedly to the snow sports context. Regarding epidemiological studies of female athletes, the same supplemental paper outlined female-specific population characteristics that can be collected when monitoring female athletes, depending on the research question or rationale for surveillance. These characteristics may include the age of menarche, menstrual cycle data (eg, cycle length, cycle phase at the point of injury/illness, ovulation status, amount of blood loss and cycle-based symptoms), contraceptive use (yes/no), type and formulation of contraception used, pregnancy status (yes/no), pregnancy stage and duration.[85] If postpartum, relevant information may include the mode of delivery for childbirth, postpartum trauma history, postpartum training data, breastfeeding status (yes/no), caregiving responsibilities and mental health status. As stated previously, only data pertinent to the specific research question should be collected. As with other sensitive data, female-specific data (eg, menstrual cycle data or pregnancy status) should not be shared with anyone who does not need it. Questions about potentially sensitive health topics should use culturally sensitive language, and relevant health data should be collected by an individual in a trusted professional role with trauma-informed skills to address potential allegations of harassment and abuse. The reporting of female-specific surveillance data should follow the STROBE-SIIS checklist adapted to include the female health domains.[20] It is important to restrict reporting to health complications only (eg, amenorrhea, iron deficiency anaemia and deep vein thrombosis) and avoid reporting normal female health domains (ie, pregnancy, menarche menstruation) as 'illnesses'.

CONCLUSION

With this snow sports-specific extension to the IOC statement, we provide helpful guidance to researchers, international and

national sports federations, and other entities collecting and reporting epidemiological data in one or more of snow sports disciplines. We hope that adoption of these guidelines will lead to improved data quality, enhanced comparability of data from different sources, and, in the long term, better protection of the health of snow sports athletes through tailored injury and illness prevention measures informed by such epidemiological data.

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