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Methods for epidemiological studies in competitive cycling: an extension of the IOC consensus statement on methods for recording and reporting of epidemiological data on injury and illness in sport 2020

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ABSTRACT

In 2020, the IOC released a consensus statement that provides overall guidelines for the recording and reporting of epidemiological data on injury and illness in sport. Some aspects of this statement need to be further specified on a sport-by-sport basis. To extend the IOC consensus statement on methods for recording and reporting of epidemiological data on injury and illness in sports and to meet the sport-specific requirements of all cycling disciplines regulated by the Union Cycliste Internationale (UCI). A panel of 20 experts, all with experience in cycling or cycling medicine, participated in the drafting of this cycling-specific extension of the IOC consensus statement. In preparation, panel members were sent the IOC consensus statement, the first draft of this manuscript and a list of topics to be discussed. The expert panel met in July 2020 for a 1-day video conference to discuss the manuscript and specific topics. The final manuscript was developed in an iterative process involving all panel members. This paper extends the IOC consensus statement to provide cycling-specific recommendations on health problem definitions, mode of onset, injury mechanisms and circumstances, diagnosis classifications, exposure, study population characteristics and data collection methods. Recommendations apply to all UCI cycling disciplines, for both able-bodied cyclists and para-cyclists. The recommendations presented in this consensus statement will improve the consistency and accuracy of future epidemiological studies of injury and illness in cycling.

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INTRODUCTION

Millions of people around the world ride bicycles for transport, enjoyment and exercise. Cycling also has a long history as a competitive sport, having been part of every modern Olympic Games since their inception in 1896. Today, there are many different disciplines of competitive cycling. The sport's governing body, the Union Cycliste Internationale (UCI), currently administers the following disciplines: road cycling, mountain biking, cyclo-cross, track cycling, bicycle motocross (BMX) racing, BMX freestyle, trials, indoor cycling (artistic cycling and cycle ball) and para-cycling.[1]

Strong evidence links cycling with a broad spectrum of health benefits and supports the promotion of cycling as an effective public health initiative.[2 3] However, as for any other sport, participation in competitive cycling involves a risk of injury and illness. Much of the previously published literature on cycling-related health problems has focused on concussion or traumatic injuries of the upper and lower limbs occurring during road races and mountain biking (online supplemental appendix 1). These studies are marked by heterogenous populations and vastly different methodologies, which complicate the interpretation and comparison of their results. Moreover, many cycling disciplines are either under-represented or not represented at all in the epidemiological literature. Hence, there is a need to standardise the recording and reporting of injuries and illnesses in cycling—across disciplines—to acquire more specific knowledge on the incidence of injuries and illnesses, their types and risk factors. This information is necessary to develop effective policies and programmes to mitigate injury and illness risk.

In February 2020, the IOC released a consensus statement on methods for recording and reporting epidemiological data on injury and illness in sport.[4] This document, hereafter referred to as the IOC consensus statement, provided general guidelines to cover all sports-related injuries and illnesses. However, it was beyond the IOC consensus statement's scope to account for all sport-specific factors that may influence its applicability in every context. The IOC consensus group recommended that sport-specific extensions of the statement be written by clinicians and scientists with in-depth knowledge of these sports.[4]

In this consensus statement, we extend aspects of the IOC consensus statement to enable consistent application of its recommendations

to epidemiological studies in cycling as a sport. The document applies to all disciplines currently regulated by the UCI, including para-cycling. We do not intend the paper to serve as a stand-alone document, but rather that it be read and applied in conjunction with the IOC consensus statement.

METHODS

For this consensus statement, we followed similar procedures as were applied in previous extensions of the IOC consensus statement.[5 6] A panel of 20 experts from 11 countries convened to produce a consensus statement on injury and illness surveillance methodology in competitive cycling. This panel included sports physicians, sports scientists, epidemiologists, physiotherapists and strength and conditioning coaches with experience in the development of young cyclists, the training of elite cyclists and the organisation and medical assistance at international competitions of all disciplines of cycling. The panel included an athlete representative (LPN), who has competed at an elite level in three UCI disciplines (road cycling, mountain biking and cyclo-cross). A consensus meeting was held by video conference in July 2020 to discuss cycling-specific injuries, illnesses and health-monitoring issues, using the IOC consensus statement as a basis.[4] In the consensus meeting, participants discussed a first draft document of a cycling extension of the IOC consensus statement, prepared by VM-P, JDC, EV and BMP, and a list of specific topics to be discussed (online supplemental appendix 2).

An expert in the epidemiology of sports-related injury (EV) moderated the consensus meeting. The meeting was recorded and transcribed by an administrative assistant. The consensus group agreed that standardising injury and illness recording in cycling is necessary and concurred that this should cover all UCI cycling disciplines. Cycling for transport and other forms of non-competitive cycling were deemed to be beyond the scope of the consensus statement. However, the group noted that many of the proposed guidelines may also be applicable in those contexts. It was agreed that the varied sport classes and impairment types of athletes competing in para-cycling add further complexity. Thus, an additional expert (CB) was recruited to ensure that the proposed translation was applicable to cyclists with impairment. After the meeting, BC, BMP and EV updated the draft manuscript to incorporate the statements agreed on by the expert panel. The manuscript was circulated in an iterative process until, after three rounds, all panel members agreed on the final version. Following the recommendation of Shrier,[7] all members were invited to provide a written minority opinion if they disagreed with any of the elements in the consensus statement. However, the panel reached agreement on all elements of the statement.

CONSENSUS RECOMMENDATIONS

Definitions of health problems, injury and illness

The IOC defines an athletic health problem as any condition that reduces an athlete's normal state of full health, irrespective of its consequences on the athlete's sports participation or performance, or whether the athlete seeks medical attention.[4] We believe this is an appropriate overarching definition for cycling research but highlight that the operational definition of a 'recordable' health problem is likely to vary between studies, depending on their research question.[8 9] Recording all health problems is recommended in studies aiming to gain a complete overview of the full spectrum of injuries and illnesses affecting cyclists, particularly those interested in capturing overuse injuries and chronic illnesses. However, a narrower definition such as if a health problem leads to time loss or medical attention may be appropriate in studies interested in traumatic injuries or major illnesses. For example, if a study is interested in rider safety during competition, a recordable health problem could be defined as one that leads to abandonment or hospitalisation.

Regarding the definitions of injury and illness, the methods for recording severity and the methods for recording multiple health problems, we consider the recommendations presented in the IOC consensus statement to be appropriate for cycling studies.

Mode of onset

Traditionally, the mode of injury onset has been classified in one of two ways: either by how quickly the injury presented (sudden onset or gradual onset) or by the assumed mechanism (single energy transfer/acute injury or repetitive energy transfer/overuse injury). The IOC consensus statement encourages researchers to develop a more nuanced classification system that accounts for mixed mechanisms and is also applicable to illnesses. Until such a system is developed and validated, we propose that cycling studies record, for all health problems, the presentation as either *sudden onset* or *gradual onset*. For injuries, the underlying mechanism should also be recorded as *acute* or *repetitive*, based on whether the injury was caused by a single or a cumulative transfer of kinetic energy. We acknowledge that this classification is based on the recorder's judgement, and for some injury types, it is likely to be inconsistently applied. However, due to its potential implications for developing prevention strategies, we believe the classification remains valuable. Cycling-specific examples of classifying the mode of injury onset are shown in table 1.

Injury mechanisms and circumstances

Improved knowledge of injury mechanisms and circumstances in cycling will guide researchers, practitioners and other stakeholders (such as governing bodies, race organisers and equipment manufacturers) to develop effective preventive interventions.[10] The IOC consensus statement provides broad definitions of injury mechanisms. In box 1, we provide examples of cycling-specific collision agents, collision mechanisms, as well as potential related circumstances that may be related to injury causation.

Most cycling disciplines take place outdoors, where the environment (including the surface) often changes between different competitions or even between different days and weeks of the same event.[11] For these reasons, environmental factors, including surface conditions, air temperature, humidity, solar radiation, wind velocity and variations in air quality (air pollution, pollen and nitrogen dioxide) are all useful measures to add context to injury and illness surveillance. This information may be added to answer specific research questions.[12–14] There are currently no recommendations on the assessment of environmental conditions in sport. Cycling is not the only sport that is undertaken outdoors, and universal recommendations should be developed to support a uniform registry of these factors.

These suggestions are not meant to be used as a definitive classification system but rather a starting point for future cycling studies and surveillance systems to develop classifications relevant to their discipline, context and the research questions being addressed.

Describing injury mechanisms and related circumstances is only relevant for sudden-onset trauma. In contrast, the mechanisms of gradual-onset conditions are harder to determine

Table 1 Cycling-specific examples of classifying the mode of injury onset

Presentation Sudden or gradual onset?*	Underlying mechanism Single or cumulative transfer of kinetic energy?	Example
Sudden onset	Acute	A mountain biker crashes during a downhill competition, landing on her shoulder. X-ray shows a clavicular fracture.
Gradual onset	Repetitive	Example 1. Over a period of 1 month, a track cyclist feels an increasing pain below his kneecap. It starts as a slight discomfort at the beginning of training that disappears after warm-up. Eventually, the pain impedes pedalling during training. Ultrasound imaging shows patellar tendinopathy. Example 2. Over the course of a single 2-hour training session, a road cyclist develops severe anterior knee pain. Based on clinical examination, she is diagnosed with patellofemoral pain syndrome.
Sudden onset	Repetitive	An artistic cyclist is performing a routine when he feels a sudden pain in his right shoulder. Ultrasound imaging shows rotator cuff tendinopathy and subacromial bursitis.

*Sudden onset=instantaneous or developing over several seconds.
Gradual onset=developing over minutes, hours or longer.

because they occur over time and are often the result of the interaction of multiple factors.

Classifying sports injury and illness diagnoses

The IOC consensus statement provides recommendations for classifying injuries based on body area, tissue type and pathology type and for classifying illnesses based on the medical system and aetiology. To record specific diagnoses, the IOC statement encourages the use of sport-specific coding systems such as the Sports Medicine Diagnostic Coding System and the Orchard Sports Injury and Illness Classification System.[15] We support these recommendations, and in table 2, we provided codes for several cycling-related conditions, including ulnar neuropathy ('handlebar palsy'),[16–19] pudendal neuropathy and other forms of cycling-related sexual and urinary dysfunction[18 20–26] and exercise-related external iliac artery flow limitations.[27–31]

In our experience, it can be challenging to record consistent diagnostic codes for certain cycling-related skin conditions. For example, if a cyclist crashes and sustains a thigh abrasion that subsequently becomes infected, the incident could potentially be recorded as both an injury (thigh abrasion), an illness (dermatological infection) or both. As the initial cause was kinetic energy transfer, we recommend that all skin abrasions be recorded as injuries (table 2). If an athlete develops a local or systemic infection that warrants treatment with oral or intravenous antibiotics, this should be recorded separately as a subsequent local illness.

'Saddle sores' located on the genitals, inner thigh, and buttocks,[32] can also be difficult to code. They are sometimes considered injuries,[32] given that mechanical forces (pressure and friction) are involved in their development. However, because the primary pathology is follicle infection and because heat, moisture, and bacteria also play a key role, we recommend that saddle sores be recorded as illnesses (table 2).

Stump lesions among disabled cyclists typically occur in the context of increased or altered mechanical forces and thus should be recorded as injuries (table 2). If the cyclist develops a secondary local or systemic infection that warrants treatment with oral or intravenous antibiotics, this should be recorded separately as a subsequent local illness.

Key injury types

Based on clinical experience and literature review (online supplemental appendix 1), we expect that most epidemiological studies of cycling are likely to record a predominance of acute sudden-onset injuries in the upper limb and shoulder and gradual-onset injuries to the knee. We recommend that studies report detailed injury data to at least the level of tissue and pathology type for those body areas. Ideally, specific diagnoses should also be reported.

Sport-related concussions remain a poorly quantified yet high priority injury problem in cycling.[33–37] The potential short-term and longer term repercussions of cyclists riding soon after suffering a concussion, before having made a full recovery, may be significant. To increase the recognition and sensitivity of the diagnosis of concussion, the UCI recently published a cycling-specific adaptation of the Sports Concussion Assessment Tool, version 5.[38 39] We encourage future studies to apply this protocol and report all concussions in as much detail as possible.

Key illness types

In studies of endurance cycling disciplines, we expect a relatively high rate of respiratory and gastrointestinal infections, as well as illnesses with allergic and environmental aetiologies (eg, hay fever, allergic and exercise-induced bronchoconstriction, heat illness and hypothermia). These illness types should be recorded and reported by both the organ system/region and the aetiology. Ideally, specific diagnoses should also be reported.

Capturing and reporting exposure

There is a wide range of cycling disciplines, each with unique characteristics. Therefore, we recommend measures of exposure specific to each UCI discipline (table 3). Risk exposure in training and competition should be reported separately using common units. If prerace warm-ups and postrace cool-down periods are recorded, it should be as training exposure.[40] In some instances, it may be appropriate to use additional measures of competition exposure (table 3).

Cycling offers a unique opportunity to quantify load in many ways, which may allow for highly accurate and novel ways of recording individual exposure. For example, power metres mounted on the bicycle or in the pedals enable real-time measurement of power output.[41–43] These data, along with other metrics such as heart rate and GPS,[44] can be used to generate a range of summary measures of training load, such as the Training Stress Score (TSS),[11] and the Training Impulse (TRIMP).[45 46] These are commonly used by cyclists and coaches to analyse and plan training and competition and have the potential to be used in studies investigating the relationship between cycling loads and injury risk.[47] As these measures encompass both cycling duration and intensity, they may also be valuable as supplementary exposure measures in basic epidemiological research. For example, injury incidence rates could be expressed per 10 000 TSS units,

Box 1 Categories of cycling-specific collision agents, collision mechanisms and related circumstances

Cyclist collided with
- A person/animal
  - Another cyclist.
  - Support staff member.
  - Spectator.
  - Official.
  - Pedestrian.
  - Animal.
- A vehicle
  - Car.
  - Motorcycle.
  - Bicycle.
- An inanimate object related to competition
  - Barrier.
  - Obstacle.
  - Advertising board.
- An inanimate object unrelated to competition
  - Street sign.
  - Kerb.
  - Fence.
  - Tree.
  - Rock.
- The ground only

Collision mechanism (multiple may apply)
- Surface quality
  - Pothole.
  - Tree-root damage.
- Equipment failure.
- Avoiding a person or animal
  - Another cyclist.
  - Support staff member.
  - Spectator.
  - Official.
  - Pedestrian.
  - Animal.
- Avoiding a loose object
  - Branch.
  - Bottle.
  - Stone/rock.
- Avoiding an inanimate object related to competition
  - Barrier.
  - Obstacle.
  - Advertising board.
- Avoiding an inanimate object unrelated to competition
  - Street sign.
  - Kerb.
  - Fence.
  - Tree.
  - Rock.
- Cyclist's own behaviour
  - Abrupt manoeuvre.
  - Braking mistake.
  - Lack of focus.
- Another cyclist's behaviour (intentional)
  - Pushing.
  - Slinging.
  - Cutting.
- Another cyclist's behaviour (unintentional)
  - Abrupt manoeuvre.
  - Braking mistake.
  - Lack of focus.
- Traffic related
  - Vehicle hitting the cyclist.
  - Cyclist hitting a vehicle.
  - Vehicle forcing the cyclist off the road.

Related circumstances (multiple may apply)
- Environmental factors
  - Wind.
  - Rain.
  - Snow.
  - Sand/dust.
  - High temperature.
  - Low temperature.
- Competition-specific factors
  - Phase of the race
    - Start.
    - Breaking away.
    - Sprint.
    - Climb.
    - Descent.
    - Feeding zone.
    - Bunch sprint.
  - Crash in a marked hazard zone
- Infringement of race or traffic regulations
  - By cyclist who crashed.
  - By another cyclist.
  - By a support staff member.
- Track surface
  - Road – asphalt.
  - Road – paved.
  - Gravel.
  - Sand.
  - Mud.
  - Wood.
  - Concrete.
- Technically difficult circuit/circuit section.
- Technically difficult routine or technical action.

as well as per 1000 hours. However, this approach has not been validated, and researchers should be aware that the same score may describe a different response to exercise. For example, a cyclist can record similar TSS and TRIMP scores from a high intensity/low volume session and a low intensity/high volume session.[48 49]

Currently, power metres, training management software and GPS are mainly used in road cycling, cyclo-cross and mountain biking. Power metres are also widely used in track cycling training, but they are currently not allowed in competition.

In disciplines where the impulses exerted on the bike are determinants of success, such as trials and BMX freestyle, cyclists are increasingly using new wearable inertial sensors comprising accelerometers and gyroscopes.[50] These may also offer the potential for discipline-specific forms of exposure measurement in future epidemiological studies.

Expressing risk

The risk of injury and illness in cycling should be reported as incidence and prevalence. The IOC consensus statement defines incidence as the number of new injuries/illnesses in the

Table 2 Recommended diagnostic codes for selected cycling-related health problems

Condition	Broad classification*	SMDCS-V2 code	OSIICS-13 code
Lateral hand numbness/ulnar neuropathy ('handlebar palsy')	Injury/wrist/nervous system/nerve injury/gradual onset, repetitive	Ulnar nerve entrapment (Tunnel of Guyon), WR.22.39	Wrist ulnar nerve injury, WNU
Numbness of the genitals or perineum/pudendal neuropathy/male or female sexual or urinary dysfunction	Injury/lumbosacral spine/nerve injury/gradual onset, repetitive	Pudendal nerve injury, LS.23.39	Pudendal nerve injury, LNP
Exercise-related iliac artery flow limitation	Injury/hip-groin/vessels/vascular trauma/gradual onset, repetitive	Exercise-related iliac artery flow limitation, HI.73.45	Exercise-related iliac artery flow limitation, GVI
Saddle sores (skin ailments on the buttocks, groin, inner thigh or genitals, related to contact with the bicycle saddle)	Illness/dermatological system/infection/gradual onset	Cellulitis/folliculitis, DE.06.75	Skin infection pelvis/buttock – including ischial abscess, MDIB
Stump lesions among cyclists with amputations	Injury/(specific body area)/stump/stump injury/(gradual or sudden onset, acute or repetitive)	See condition-specific codes: XX.91.00	Stump trauma, region-specific codes: UWS, QWS, TWS, EWS, RWS and KWS.

*Based on the IOC consensus categories. Injuries: body area/tissue type/pathology type/mode of onset; Illnesses: medical system/aetiology/mode of onset.
EWS, stump trauma elbow; KWS, stump trauma knee; QWS, stump trauma lower limb; RWS, stump trauma forearm; TWS, stump trauma thigh; UWS, stump trauma upper arm.

population that develop during a specified period.[4] Prevalence is a proportion that refers to the number of existing cases at a given point in time (point prevalence) or in a specific period (period prevalence) divided by the total population at risk.[4] A survey of top-level road cyclists showed that injuries occurred more frequently in training than in competition but that competition-related injuries were more severe.[51] We, therefore, recommend that incidence is calculated separately for training and competition. Depending on the cycling discipline, we recommend expressing the number of injuries per 1000 hours, race days, starts, runs, matches or routines (table 3). We do not recommend expressing the number of injuries per 1000 km (or any other distance), because the demands of riding the same distance can vary greatly in different conditions (eg, flat vs mountainous terrain).

To compare injury and illness incidence between groups of cyclists with fundamentally different types of preferred exposure (eg, sprint and endurance track cycling, cross-country and downhill mountain biking, BMX racing and BMX freestyle), rates should be calculated per 365 athlete-days.

Study population characteristics

As a minimum, the following population characteristics should be recorded: age, sex, cycling discipline, level of cycling, and in para-cycling, the rider's sport classification, impairment type and diagnosis (table 4).

Depending on the research question, other relevant characteristics such as height, body mass, training and competition volume (hours/week), years of competitive experience in the relevant age category and previous health problem(s) may be relevant. Studies of elite cyclists should report, while respecting confidentiality, the approximate range of UCI rankings of the participants.

The level of cycling can be defined as recreational, amateur or professional. A recreational cyclist is defined as someone who cycles as a regular form of exercise without participating in competitions. An amateur is a cyclist who practices cycling for non-economic reasons, irrespective of whether they participate in official competitions. A professional is a cyclist who receives salary or income for their involvement in the sport. This classification is mostly relevant for road cycling, which is the discipline with the largest number of professionals (particularly among males). In other disciplines, it may be more pertinent to classify cyclists as recreational, subelite and elite. In general, we define an elite cyclist as one who competes at a high national or international level in their chosen discipline and age group. However, this is likely to vary substantially between countries, disciplines and age groups. We, therefore, encourage all cycling researchers to describe the competitive level of their subjects in detail to facilitate comparison between studies.

UCI competitions such as the World Championships are held separately for males and females and according to a range of age categories including 'Junior' (17 and 18 years), 'Under 23' (19–22 years) and 'Elite' (23 years and older). Some disciplines also include the categories of 'Youth' (16 years and under) and 'Masters' (30 years and older, with 5-year subcategories). These categories may be appropriate for use in epidemiological studies. However, it would be preferable to combine the Under 23 and Elite categories in many cases because many elite cycling competitions do not differentiate between these groups (eg, most professional road cycling races, Olympic Games and BMX World Championships). Additionally, to avoid conflicting terminology and allow universal application, we recommend that epidemiological studies use the term 'Adult' instead of 'Elite' when referring to the (open) category for adults.

Study design and data collection methods

Epidemiological studies in cycling should ideally have a prospective design. Depending on the resources and study question at hand, other designs, however, can also be considered. The current recommendations should remain applicable. Depending on the context of surveillance, it may be appropriate to collect data using team medical personnel, race medics, coaches and/or from cyclists themselves. All study protocols should be approved by an appropriate ethical review committee and conform to the World Medical Association's code of ethics.[52] Each cyclist should be adequately informed of what is expected from him or her, the duration of the data collection, the possible risks and benefits of study participation, the reporting of results (at individual or group level) and sign an informed consent form. For research with minors, permission from at least one parent or legal guardian is required, in addition to the assent of the child. The data must be stored in a secure format to preserve confidentiality, and all handling of sensitive data must comply with local and regional data security regulations.

Ideally, data should be collected using electronic registration systems. In cases where paper registrations are necessary, we encourage the use of the IOC consensus statement's Daily Medical Report on Injuries and Illnesses.

Table 3 Recommended exposure measures for each UCI cycling discipline

Discipline	Events/subdiscipline	Preferred exposure measures
Road cycling	► All events, including para-cycling.	1000 hours of training/ competition. 100 race days.*
Track cycling	Sprint events, including para-cycling ► Individual sprint. ► Team sprint. ► 1000 m/500 m time trial. ► Keirin. ► Para-cycling only: tandem sprint.	100 starts.
	Endurance events, including para-cycling ► Individual pursuit. ► Team pursuit. ► Points race. ► Madison. ► Scratch race.	1000 hours of training/ competition.
Mountain bike	Endurance events ► Mountain bike cross-country. ► Enduro. ► Eliminator. ► E-mountain bike.	1000 hours of training/ competition. 100 race days.*
	Non-endurance events ► Mountain bike downhill. ► Four-cross. ► Alpine snow bike.	100 runs.
Cyclo-cross	► All events.	1000 hours of training/ competition. 100 race days*
BMX	► Racing – all events.	1000 hours of training/ competition. 100 runs.
	► Freestyle park competition.	1000 hours of training/ competition. 100 runs.
Trials	All events.	1000 hours of training/ competition 100 runs
Indoor cycling	Artistic cycling and all events.	1000 hours of training/ competition. 100 routines.
	Cycle ball.	1000 hours of training/ competition. 100 matches.

*Supplementary measure of competition exposure.
UCI, Union Cycliste Internationale.

Table 4 Classification scheme for elite para-cycling

Equipment	Classification category	Impairment types and examples of associated diagnoses
Bicycle	C division (C1–C5)	Impaired muscle power ► Spinal cord disorders and muscular dystrophy. Impaired passive range of motion ► Arthrogryposis and joint contracture. Leg length difference ► Dysmelia. Limb deficiency ► Traumatic or non-traumatic amputation. Hypertonia/ataxia/athetosis ► Cerebral palsy, brain injury and stroke.
Tricycle	T division (T1–T2)	Hypertonia/ataxia/athetosis ► Cerebral palsy, brain injury and stroke.
Handcycle	H division (H1–H5)	Impaired muscle power ► Spinal cord disorders and muscular dystrophy. Impaired passive range of motion ► Arthrogryposis and joint contracture. Limb deficiency ► Traumatic or non-traumatic amputation. Hypertonia/ataxia/athetosis ► Cerebral palsy, brain injury and stroke.
Tandem bicycle	B division	Visual impairment.

CALL TO ACTION

In this paper, we have extended the recommendations of the IOC consensus statement, such that they can be consistently applied to epidemiological studies across UCI cycling disciplines.

The scientific literature on injuries and illnesses in cycling is currently marked by studies with heterogeneous methodology, many of which involve small numbers of participants or have a short period of data collection. For many cycling disciplines, no epidemiological information is available. This is concerning, as such information is the cornerstone of the development of measures protecting athletes' health. We foresee that this consensus statement will facilitate new, high-quality epidemiological research across all cycling disciplines and levels and among under-represented athlete groups.

We draw attention to para-cyclists who have received little research attention to date. Given that para-athletes often have a complex medical background, it is of utmost importance to implement surveillance programmes to guide and promote athlete safety in this athletic population.

We also highlight the recent IOC Consensus statement on relative energy deficiency in sport .[53] This is a highly relevant issue for cyclists of both sexes and has received little research attention to date.

The ultimate goal of epidemiological research in cycling is to guide protection and optimisation of cyclists' health. The UCI has recently made substantial efforts towards this goal, particularly in elite road cycling, with the planned introduction of a range of practical measures dedicated to rider safety.[54] We applaud these efforts and hope that this consensus statement provides a framework by which their effect can be evaluated, along with future preventative interventions across all disciplines and levels of cycling.

CONCLUSION

This extension of the IOC consensus statement will improve the consistency, accuracy and quality of injury and illness surveillance programmes across all UCI cycling disciplines.

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REFERENCES

1 Union Cycliste Internationale, 2020. Available: https://www.uci.org/ [Accessed 17 Mar 2021].
2 Oja P, Titze S, Bauman A, *et al*. Health benefits of cycling: a systematic review. *Scand J Med Sci Sports* 2011;21:496–509.
3 Bauman AE, Rissel C. Cycling and health: an opportunity for positive change? *Med J Aust* 2009;190:347–8.
4 Bahr R, Clarsen B, Derman W, *et al*. International Olympic Committee consensus statement: methods for recording and reporting of epidemiological data on injury and illness in sport 2020 (including STROBE extension for sport injury and illness surveillance (STROBE-SIIS)). *Br J Sports Med* 2020;54:372–89.
5 Verhagen E, Clarsen B, Capel-Davies J, *et al*. Tennis-specific extension of the International Olympic Committee consensus statement: methods for recording and reporting of epidemiological data on injury and illness in sport 2020. *Br J Sports Med* 2021;55:9–13.
6 Murray A, Junge A, Robinson PG, *et al*. International consensus statement: methods for recording and reporting of epidemiological data on injuries and illnesses in golf. *Br J Sports Med* 2020;54:1136–41.
7 Shrier I. Consensus statements that fail to recognise dissent are flawed by design: a narrative review with 10 suggested improvements. *Br J Sports Med* 2021;55:545–9.
8 Nielsen RO, Shrier I, Casals M, *et al*. Statement on methods in sport injury research from the 1st methods matter meeting, Copenhagen, 2019. *Br J Sports Med* 2020;54:941.
9 Clarsen B, Bahr R. Matching the choice of injury/illness definition to study setting, purpose and design: one size does not fit all! *Br J Sports Med* 2014;48:510–2.
10 Bahr R, Krosshaug T. Understanding injury mechanisms: a key component of preventing injuries in sport. *Br J Sports Med* 2005;39:324–9.
11 Halson SL. Monitoring training load to understand fatigue in athletes. *Sports Med* 2014;44 Suppl 2:139–47.
12 Racinais S, Nichols D, Travers G, *et al*. Health status, heat preparation strategies and medical events among elite cyclists who competed in the heat at the 2016 UCI road world cycling Championships in Qatar. *Br J Sports Med* 2020;54:1003–7.
13 Pollastri L, Macaluso C, Vinetti G, *et al*. Follow-Up of acute respiratory disorders in cyclists competing in the 100th Giro d'Italia. *Int J Sports Med* 2021;42:234–40.
14 Killops J, Sewry NA, Schwellnus M, *et al*. Women, older age, faster cycling speed and increased wind speeds are independent risk factors for acute injury-related medical encounters during a 109 Km mass community-based participation cycling event: a 3-year study in 102251 race starters-SAFER XII. *Inj Prev* 2020. doi:10.1136/injuryprev-2020-043874. [Epub ahead of print: 28 Aug 2020].
15 Orchard JW, Meeuwisse W, Derman W, *et al*. Sport medicine diagnostic coding system (SMDCS) and the orchard sports injury and illness classification system (OSIICS): revised 2020 consensus versions. *Br J Sports Med* 2020;54:397–401.
16 Patterson JMM, Jaggars MM, Boyer MI. Ulnar and median nerve palsy in long-distance cyclists. *Am J Sports Med* 2003;31:585–9.
17 Brubacher JW, Leversedge FJ. Ulnar neuropathy in cyclists. *Hand Clin* 2017;33:199–205.
18 Kennedy J. Neurologic injuries in cycling and bike riding. *Neurol Clin* 2008;26:271–9.
19 Richmond DR. Handlebar problems in Bicycling. *Clin Sports Med* 1994;13:165–73.
20 Andersen KV, Bovim G. Impotence and nerve entrapment in long distance amateur cyclists. *Acta Neurol Scand* 1997;95:233–40.
21 Awad MA, Gaither TW, Murphy GP, *et al*. Cycling, and male sexual and urinary function: results from a large, multinational, cross-sectional study. *J Urol* 2018;199:798–804.
22 Baran C, Mitchell GC, Hellstrom WJG. Cycling-Related sexual dysfunction in men and women: a review. *Sex Med Rev* 2014;2:93–101.
23 Gaither TW, Awad MA, Murphy GP, *et al*. Cycling and female sexual and urinary function: results from a large, multinational, cross-sectional study. *J Sex Med* 2018;15:510–8.
24 Leibovitch I, Mor Y. The vicious cycling: bicycling related urogenital disorders. *Eur Urol* 2005;47:277–87.
25 Partin SN, Connell KA, Schrader SM, *et al*. Les Lanternes Rouges: the race for information about Cycling-Related female sexual dysfunction. *J Sex Med* 2014;11:2039–47.
26 Silbert PL, Dunne JW, Edis RH, *et al*. Bicycling induced pudendal nerve pressure neuropathy. *Clin Exp Neurol* 1991;28:191–6.
27 Schep G, Bender MH, Kaandorp D, *et al*. Flow limitations in the iliac arteries in endurance athletes. current knowledge and directions for the future. *Int J Sports Med* 1999;20:421–8.
28 Abraham P, Bouyé P, Quéré I, *et al*. Past, present and future of arterial endofibrosis in athletes: a point of view. *Sports Med* 2004;34:419–25.
29 Abraham P, Saumet JL, Chevalier JM. External iliac artery endofibrosis in athletes. *Sports Med* 1997;24:221–6.
30 Bender MHM, Schep G, de Vries WR, *et al*. Sports-Related flow limitations in the iliac arteries in endurance athletes: aetiology, diagnosis, treatment and future developments. *Sports Med* 2004;34:427–42.
31 Lim CS, Gohel MS, Shepherd AC, *et al*. Iliac artery compression in cyclists: mechanisms, diagnosis and treatment. *Eur J Vasc Endovasc Surg* 2009;38:180–6.
32 Bury K, Leavy JE, Lan C, *et al*. A saddle sores among female competitive cyclists: a systematic scoping review. *J Sci Med Sport* 2021;24:357–67.
33 Greve MW, Modabber MR. An epidemic of traumatic brain injury in professional cycling. *Clin J Sport Med* 2012;22:81–2.
34 Elliott J, Anderson R, Collins S, *et al*. Sports-Related concussion (Src) assessment in road cycling: a systematic review and call to action. *BMJ Open Sport Exerc Med* 2019;5:e000525.
35 Heron N, Elliott J, Jones N, *et al*. Sports-Related concussion (Src) in road cycling: the roadside heaD injury assEssment (ride) for elite road cycling. *Br J Sports Med* 2020;54:127–8.
36 Rice S, Iaccarino MA, Bhatnagar S, *et al*. Reporting of Concussion-Like symptoms after cycling crashes: a survey of competitive and recreational cyclists. *J Athl Train* 2020;55:11–16.
37 Helmich I, von Götz D, Emsermann C, *et al*. Not just contact sports: significant numbers of sports-related concussions in cycling. *J Sports Med Phys Fitness* 2019;59:496–501.

38 McCrory P, Meeuwisse W, Dvořák J, *et al*. Consensus statement on concussion in sport-the 5th international conference on concussion in sport held in Berlin, October 2016. *Br J Sports Med* 2017;51:838–47.
39 Union Cycliste Internationale. Harrogate consensus agreement: Cycling-specific sport-related concussion, 2020. Available: https://www.uci.org/docs/default-source/medical/2020-uci-cycling-specific-sport-related-concussion-protocol.pdf [Accessed 17 Mar 2021].
40 Pluim BM, Fuller CW, Batt ME, *et al*. Consensus statement on epidemiological studies of medical conditions in tennis, April 2009. *Br J Sports Med* 2009;43:893–7.
41 Lillo-Beviá JR, Courel-Ibáñez J, Cerezuela-Espejo V, *et al*. Is the functional threshold power a valid metric to estimate the maximal lactate steady state in cyclists? *J Strength Cond Res* 2019;Publish Ahead of Print.
42 Mateo M, Blasco-Lafarga C, Zabala M. Pedaling power and speed production vs. technical factors and track difficulty in bicycle Motocross cycling. *J Strength Cond Res* 2011;25:3248–56.
43 Sanders D, Abt G, Hesselink MKC, *et al*. Methods of monitoring training load and their relationships to changes in fitness and performance in competitive road cyclists. *Int J Sports Physiol Perform* 2017;12:668–75.
44 Muriel X, Courel-Ibáñez J, Cerezuela-Espejo V, *et al*. Training load and performance impairments in professional cyclists during COVID-19 Lockdown. *Int J Sports Physiol Perform* 2020;1:1–4.
45 Padilla S, Mujika I, Orbañanos J, *et al*. Exercise intensity during competition time trials in professional road cycling. *Med Sci Sports Exerc* 2000;32:850–6.
46 Padilla S, Mujika I, Orbananos J. Exercise intensity and load during mass-start stage races in professional road cycling. *Med Sci Sports Exerc* 2001;33:796–802.
47 Soligard T, Schwellnus M, Alonso J-M, *et al*. How much is too much? (Part 1) International Olympic Committee consensus statement on load in sport and risk of injury. *Br J Sports Med* 2016;50:1030–41.
48 van Erp T, Sanders D, de Koning JJ. Training characteristics of male and female professional road cyclists: a 4-year retrospective analysis. *Int J Sports Physiol Perform* 2019;1:1–7.
49 van Erp T, Hoozemans M, Foster C, *et al*. The influence of exercise intensity on the association between kilojoules spent and various training loads in professional cycling. *Int J Sports Physiol Perform* 2019;14:1395–400.
50 Camomilla V, Bergamini E, Fantozzi S, *et al*. Trends supporting the in-field use of wearable inertial sensors for sport performance evaluation: a systematic review. *Sensors* 2018;18:873.
51 De Bernardo N, Barrios C, Vera P, *et al*. Incidence and risk for traumatic and overuse injuries in top-level road cyclists. *J Sports Sci* 2012;30:1047–53.
52 World Medical Association. Wma Declaration of Helsinki – ethical principles for medical research involving human subjects. Available: https://www.wma.net/policies-post/wma-declaration-of-helsinki-ethical-principles-for-medical-research-involving-human-subjects/ [Accessed 17 Mar 2021].
53 Mountjoy M, Sundgot-Borgen JK, Burke LM, *et al*. IOC consensus statement on relative energy deficiency in sport (RED-S): 2018 update. *Br J Sports Med* 2018;52:687–97.
54 Union Cycliste Internationale. Road cycling: the UCI announces the introduction of numerous measures to improve rider safety as of 2021. Available: https://www.uci.org/inside-uci/press-releases/road-cycling-the-uci-announces-the-introduction-of-numerous-measures-to-improve-rider-safety-as-of-2021 [Accessed 17 Mar 2021].

Appendix 1. The incidence and prevalence of injuries and illnesses in road and track cycling, mountain biking, BMX and para-cycling

Reference	Discipline	Sex	n	Level	Age	Recordable injury or illness	Study design	Incidence and prevalence	
Aitken, 2011 [1]	MTB	M/F	130900	Recreational	31.5 (men) (range 10-66) 32.0 (women) (range 11-63)	Injuries for which participants sought medical care at one of five medical facilities	One-year prospective study	1.54/1000 biker exposures (overall) 1.64/1000 biker exposures (M) 1.08/1000 biker exposures (F)	
Barrios, 1997 [2]	Road	M	65	Professional	25 (range 21-32)	Overuse and traumatic lesions diagnosed by team doctors, trainers and physiotherapists	Retrospective study of injuries recorded from 1983 to 1995	*Overuse* 0.17/year 0.86/5 years 0.005/1000 km 0.002/comp day	*Trauma* 0.11/year 0.54/5 years 0.003/1000 km 0.001/comp day
Becker, 2013 [3]	MTB (DH)	M/F	249	Different levels	23.5 ± 6.8 (range 14-53)	Any injury resulting from training or competition, irrespective of medical treatment requirement or time loss from sports activities	Monthly e-mail prospective survey over 6 months (April-September 2011)	Overall Experts Professionals Competition Practice	16.8/1000 h 17.9/1000 h 13.4/1000 h 20/1000 h 13/1000 h
Brøgger-Jensen, 1990 [4]	BMX	M/F	976	Elite	Range 6 - 40	Injuries for which participants received medical assistance by first aid on-site	Injuries during 2-day BMX Cycling European Championship 1989	*2-day cumulative incidence* 6.3% (61/976 riders) 5.6% (men); 9.4% (women) *Incidence* 1190/1000 h*	
Chow, 1993 [5]	MTB	M/F	222 M 46 F	Different levels	36.2 ± 9.4 (range 14-68)	The presence of pain, discomfort or disability	Retrospective survey over the last year	*1-year cumulative incidence* 51.1% (137/268)	
Clarsen, 2010 [6]	Road	M	109	Professional	26 ± 4	Injuries that required attention from medical personnel or time loss from cycling were registered	Retrospective survey with interviews on overuse injuries during the last year	*1-year cumulative incidence* 58% (63/109) low back pain 36% (39/109) anterior knee pain *Incidence* 0.862/year 0.954/1000 h	
Clarsen, 2015 [7]	Road	M/F	98	Junior, semi-professional	NR	All physical complaints, regardless of their	Weekly e-mail prospective	*Body part* Knee	*13-week average prevalence (95% CI)*

				and professional		consequence on sports participation or performance	survey during 13 weeks	Lower back Shoulder Anterior thigh	23% (17-28) 16% (12-20) 7% (4-10) 8% (7-9)	
De Bernardo, 2012 [8]	Road	M	51	Professional	25.8 ± 4.4	Injuries that resulted in a time-loss of at least one day from training or competition	Retrospective study with interviews of injuries during the last 4 years	*Overuse* 0.259/year 1.039/racer 0.010/1000 km 0.0036/comp day	*Trauma* 0.245/year 0.980/racer 0.008/1000km 0.0034/comp day	*Overall* 0.5/year 2.02/racer 0.018/1000 km 0.007/comp day
Decock, 2016 [9]	Road	M/F	3311 (in 2002) 4487 (in 2012)	Different levels	NR	All reported accident files	Retrospective study on reported injuries in 2002 and 2012	*Year* 2002 2012	*1-year cumulative incidence* 15.8% (525/3311) 15.7% (705/4487)	
Derman, 2018a [10]	Para-Cycling (track and road)	M/F	138 66	Paralympic	NR	Any new injury or exacerbation of previous injury that required medical attention	Prospective study during Rio 2016 Summer Paralympic Games	*Cumulative incidence during Paralympic Games* 9.8% 7.0/1000 athlete days (range 4.5-10.9)		
Derman, 2018b [11]	Para-Cycling (track and road)	M/F	138 66	Paralympic	NR	Any new illness or exacerbation of pre-existing illness that required medical attention	Prospective study during Rio 2016 Summer Paralympic Games	*Cumulative incidence during Paralympic Games* 13.2% 10.5/1000 athlete days (range 7.3-15.0)		
Engebretsen, 2013 [12]	BMX MTB Road Track	M/F	48 76 210 167	Professional	NR	All musculoskeletal complaints or concussions (injuries) incurred during competition or training, receiving medical attention	Prospective study during the Olympic Games, London 2012	*Cumulative incidence during Olympic Games* 31.1% (15/48) 21.1% (16/76) 9.0% (19/210) 3.0% (5/167)		
Gaulrapp, 2001 [13]	MTB	M/F	3873	Different levels	25 (range 8 - 80)	All injuries that prevented the athlete from at least one day of mountain biking	Retrospective survey of all injuries sustained during their period of participation in	*Incidence* 0.6/year 1.1/1000 h		

							the sport		
Haeberle, 2018 [14]	Road	M	1584	Professional	30	All injuries that forced the cyclist to withdraw from the Tour de France	Retrospective study of injuries during the Tour de France 2010-2017	*Cumulative incidence over 8 Tour de France races* 16% (259/1584)	
Himmelreich, 2007 [15]	MTB	M/F	106	Professional	23.1	Acute injuries that occurred during competition and that prevented riders from finishing the race	Retrospective survey of severe injuries during the last 2 years	*Incidence* *Downhill:* 1.08/1000 h *Cross-country:* 0.39/1000 h	
Kronisch, 1996a [16]	MTB	M/F	3624	Different levels	NR	Any episode of acute trauma sustained during competition that required medical attention and rendered the rider unable to complete the event	Prospective study during 5 days of off-road cycling events	*5-day cumulative incidence* 0.4% (16/3624)	
Kronisch, 1996b [17]	MTB	M/F	4074 (CC) 2158 (DH)	NR	NR	Injuries that occurred during competition and that prevented riders from finishing the race	Prospective study at three multi-day cycling events in 1995	*Incidence* *Cross-country* 3.1/1000 h (M) 7.5/1000 h (F)	*Incidence* *Downhill* 42.7/1000 h (M) 46.8/1000 h (F)
Kronisch, 2002 [18]	MTB	M/F	20769	Elite	28.4 (range 15-59) 30.8 (range 22-52)	Injuries that occurred during competition and that prevented riders from finishing the race	Annual study during 4-day event, from 1994 to 2001	*Cumulative incidence over eight 4-day races* 0.40% (71/17900) (M) 0.77% (22/2869) (F)	
Kronisch, 1994 [19]	MTB	M/F	200 M 65 F	Different levels	30.2 (range 10-56)	All injuries sustained while mountain biking during the preceding 12 months	Retrospective survey of injuries during the last year	*1-year cumulative incidence* 22.6% (60/265)	
Lareau, 2011 [20]	MTB	M/F	448	Different levels	NR	Injuries for which medical attention was sought plus obvious injuries	Survey of injuries during several endurance and cross-country races	*Race incidence* Cross-country 7.2% (8/111)	*Race incidence* Endurance 5.0% (17/337)
McGrath,	MTB	NR	52	NR	NR		Prospective	*Cumulative incidence during 7-stage race*	

2012 [21]							study during 7-stage race 2010	42.3% (22/52)
Pfeiffer, 1994 [22]**	MTB (CC)	M/F						6.8 (per 1000 h) 12 (per 1000 h)
Roi, 2014 [23]	Road	NR	NR	Different levels	NR	Request for medical assistance	Study during 6 consecutive annual amateur cycling races, from 2006 - 2011	*Cumulative incidence during 6 races* 1.7% 0.11inj/1000 km 0.011 withdrawals/1000 km
Soligard, 2017 [24]	BMX MTB Road Track	M/F	NR	Professional	NR	All musculoskeletal complaints or concussions (injuries) incurred during competition or training, receiving medical attention	Prospective study during the Olympic Games, Rio de Janeiro 2016	*Cumulative incidence during Olympic Games 2016* BMX 38% MTB 24% Road 6% Track 6%
Stoop, 2019 [25]	MTB	M	15 41	Elite Amateur	32.5 ± 12.1 40.7 ± 7.6	The presence of pain, discomfort or disability	Retrospective survey on cycling years	*Incidence* 39/1000 h 0.52/1000 h
Taylor, 1995 [26]	Wheelchair racing	M/F	41 M 12 F	Elite and non-elite	NR	Pain in any part of the body that prevented the athlete from training or competing for at least 1 day	Retrospective survey on injuries in the last 12 months	*1-year cumulative incidence* 72% (38/53
Wilber, 1995 [27]	Road & MTB	M/F	294 M 224 F	Recreational	40.4 ± 10.7 36.6 ± 9.1	Overuse: any discomfort, pain, swelling, bruising, which occurred before, during, or after cycling.	Retrospective survey of injuries during the last year	*1-year cumulative incidence* 24.5% acute (127/518) 84.9% overuse (440/518)
Willick, 2013 [28]	Para-cycling Track Road	M/F	92	Paralympic	NR	Any sport-related musculoskeletal or neurological complaint prompting an athlete to seek medical attention	Prospective study during the Paralympic Games, London 2012	*Cumulative incidence during Paralympic Games* Track 13.0% 9.3/1000 athlete days (range 4.8-16.2) Road 9.3% 9.3/1000 athlete days (range 3.9-10.7)
Yanturali, 2015 [29]	Road	M	166	Professional	28.7	Injury: a physical complaint or observable damage to body tissue produced by the transfer	Prospective study during 8-day tour	*Incidence during 8-day competition* 2.82 injuries /1000 h 3.01 illnesses /1000 h

								of energy experienced or sustained during a race. Illness: a physical complaint or presentation not related to injury.	

Note. CC = cross-country; comp = competition; DH = downhill; F = female; h = hour; inj = injury; M = male; MTB = mountain bike; n = number of participants; NR = not reported

*Reported incidence is not in line with other research findings

**Original data not available, data is from Ansari and colleagues [30]

References

1. Aitken SA, Biant LC. Recreational mountain biking injuries. Emerg Med 2011;28:274-9.
2. Barrios C, Sala D, Terrados N, Valenti JR. Traumatic and overuse injuries in elite professional cyclists. Sports Exerc Inj 1997;3:176-9.
3. Becker J, Runer A, Neunhäuserer D, et al. A prospective study of downhill mountain biking injuries. Br J Sports Med 2013;47:458-62.
4. Brøgger-Jensen T, Hyass I, Bugge S. Injuries at the BMX Cycling European Championship. Br J Sports Med 1990;24:269-70.
5. Chow TK, Bracker MD, Patrick K. Acute injuries from mountain biking. West J Med 1993;159:145-8.
6. Clarsen B, Krosshaug T, Bahr R. Overuse injuries in professional road cyclists. *Am J Sports Med* 2010;**38**:2494–501.
7. Clarsen B, Bahr R, Heymans MW, et al. The prevalence and impact of overuse injuries in five Norwegian sports: Application of a new surveillance method. Scand J Med Sci Sport 2015:25:323-30.
8. De Bernardo N, Barrios C, Vera P, *et al.* Incidence and risk for traumatic and overuse injuries in top-level road cyclists. *J Sports Sci* 2012;**30**:1047–53.
9. Decock M, De Wilde L, Vanden Bossche L, et al. Incidence and aetiology of acute injuries during competitive road cycling. *Br J Sports Med* 2016;**50**:669-72.
10. Derman W, Runciman P, Schwellnus M, et al. High precompetition injury rate dominates the injury profile at the RIO 2016 Summer Paralympic Games: a prospective cohort study of 51198 athlete days. Br J Sports Med 2018;52:24-31.
11. Derman W, Schwellnus MP, Jordaan E, et al. Sport, Sex and age increase risk of illness at the Rio 2016 Summer Paralympic Games: a prospective cohort study of 51 198 athlete days. Br J Sports

Med 2018;52:17-23.

12. Engebretsen L, Soligard T, Steffen K, et al. Sports injuries and illnesses during the London Summer Olympic Games 2012. Br J Sports Med 2013;47:407-14.
13. Gaulrapp H, Weber A, Rosemeyer B. Injuries in mountain biking. Knee Surg Sports Traumatol Arthrosc 2001;9:48-53.
14. Haeberle HS, Navarro SM, Power EJ, *et al.* Prevalence and epidemiology of injuries among elite cyclists in the Tour de France. *Orthop J Sports Med* 2018;6:2325967118793392.
15. Himmelreich H, Pralle H, Vogt L, Banzer W. Mountainbikeverletzungen bei Leistungs- und Breitensportlern. Sportverletzung Sportschaden 2007;21:180-4.
16. Kronisch RL, Chow TK, Simon LM, Wong PF. Acute injuries in off-road bicycle racing. Am J Sports Med 1996a;24:88-93.
17. Kronisch RL, Pfeiffer RP, Chow TK. Acute injuries in cross-country and downhill off-road bicycle racing. Med Sci Sports Exerc 1996b:28:1351-5.
18. Kronisch RL, Pfeiffer RP, Chow TK, Hummel CB. Gender differences in acute mountain bike racing injuries. Clin J Sports Med 2002;12:158-64.
19. Kronisch RL, Rubin AL. Traumatic injuries in off-road bicycling. Clin J Sport Med 1994;4:240.
20. Lareau SA, McGinnis HD. Injuries in mountain bike racing: frequency of injuries in endurance versus cross country mountain bike races. Wilderness Environ Med 2011;22:222-7.
21. McGrath TM, Yehl MA. Injury and illness in mountain bicycle stage racing: experience from the Trans-Sylvania Mountain Bike Epic Race. Wilderness Environ Med 2012;23:356-9.
22. Pfeiffer RP. Off-road bicycle racing injuries – the NORBA Pro/Elite category. Care and Prevention. Clin Sports Med 1994;13:207-18.
23. Roi GS, Tinti R. Requests for medical assistance during an amateur road cycling race. Accid Anal Prev 2014;73:170-3.
24. Soligard T, Steffen K, Palmer D, et al. Sports Injury and illness incidence in the Rio de Janeiro

2016 Olympic Summer Games: a prospective study of 11274 athletes from 207 countries. Br J Sports Med 2017;51:1265-71.

25. Stoop R, Hohenaur E, Vetsch T, et al. Acute injuries in male elite and amateur mountain Bikers: results of a survey. *J Sports Sci Med* 2019;18:207-12.
26. Taylor D, Williams T. Sports injuries in athletes with disabilities: wheelchair racing. Paraplegia 1995;33:296-9.
27. Wilber CA, Holland GJ, Madison RE, Loy SF. An epidemiological analysis of overuse injuries among recreational cyclists. Int J Sports Med 1995;16:201-6.
28. Willick SE, Webborn N, Emery C, et al. The epidemiology of injuries at the London 2012 Paralympic Games. Br J Sports Med 2013;47:426-32.
29. Yanturali S, Canacik O, Karsli E, Suner S. Injury and illness among athletes during a multi-day elite cycling road race. Phys Sportsmed 2015;43:348-54.
30. Ansari M, Nourian R, Khodae M. Traumatic and overuse injuries in elite professional cyclists. Curr Sports Med Rep 2017;16:404-12.

Appendix 2. Topics to be discussed

Injury definition

The IOC defines an athletic health problem as any condition that affects an athlete's normal state of full health, irrespective of its consequences on the athlete's sports participation or performance, or whether the athlete sought medical attention.

Proposal: to follow this IOC definition for cycling-related injury and illness episodes and record all complaints raised by the cyclist, irrespective of the need for medical attention or time loss of training and competition.

Mode of onset

The IOC consensus statement recommends implementing methods that capture relevant subtleties of injury onset, rather than using sudden and gradual onset only.

Proposal: a more sophisticated classification that includes four primary categories, combining the mechanism (acute or repetitive) and the mode of onset (sudden or gradual) (Table 2).

Subsequent health problems, recurrent health problems, and exacerbation of health problems

IOC consensus statement:

Subsequent injuries to the same location and tissue as the index injury are recurrences if the index injury was healed/fully recovered; they are exacerbations if the index injury was not fully healed/recovered.
Injuries are defined as subsequent new injuries if they i) affect the same site but other tissues or ii) affect other sites.

Subsequent illnesses to the same system and types of the index illness are recurrences if the individual has fully recovered from the index illness, and exacerbations if the individual has not yet recovered from the index illness.
Illnesses are defined as subsequent new illnesses if they i) affect the same system but other diagnosis or ii) affect other systems.

Proposal: to follow the terminology of the IOC Consensus Statement for subsequent and recurrent health problems and exacerbation of health problems:

Classifying sports injury and illness diagnoses

IOC consensus statement: see Table 5 on page 378 and Table 9 on page 380 of the IOC consensus statement.

Proposal: to follow the categories of tissue and pathology types for injuries and illnesses as recommended by the IOC consensus statement.

Severity of health problems: time-loss

IOC consensus statement: The number of days that the athlete is unavailable for training and competition, from the date of onset until the athlete is fully available for training and competition.

Proposal: to follow the terminology of the IOC Consensus Statement on the severity of health problems

Capturing and reporting athlete exposure

Proposal: to record and report injuries and illnesses specific to each discipline

Expressing risk

Proposal: to calculate incidence separately for training and competition and to express risk as injuries per 1000 h of either cycling training or competition.

Injury and illness report forms

Proposal: To include cycling-specific forms

Cycling event groups

Proposal: to use the categories presented in Table 1.