Practical Guidelines for Athlete's Injury and Illness Surveillance: A Narrative Review

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Review

Practical Guidelines for Athlete's Injury and Illness Surveillance: A Narrative Review

Federico Genovesi[1], Tindaro Bongiovanni[2], Elena Pasquali[3], Alessio Rossi[4], Marco Tabone[5], Stefano Nuara[6], Andrea Perali[3], Ben Clarsen[7]

Affiliation addresses are listed at the end of the article.

ABSTRACT

Introduction Sports participation entails a considerable risk of injury and prevention of health problems is an important goal for clinicians and researchers. A carefully designed injury and illness surveillance program, accurate data capture and careful analysis of data are building blocks for the implementation of prevention programs.

Methods We included in our narrative review papers addressing definitional issues and how to report data on injury and illness surveillance, papers addressing how to explore impact and effectiveness of surveillance procedures for sports injuries and illnesses and papers comparing different surveillance approaches.

Results Different methods and approaches alongside key definitions and concepts on health problem surveillance have been proposed during the last 30 years trying to address the main features clinicians and researchers should adopt to conduct appropriate injury and illness surveillance.

Conclusions The literature suggests that the collection of a core set of variables including location, tissue and pathology type, relation to sports activity, mode of onset, mechanism, and severity is needed to conduct appropriate injury and illness surveillance. Definitions and modalities should be clarified at the beginning of the surveillance and data collection should be safe and on time.

Keywords injury, illness, prevention, health, surveillance

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Correspondence Dr. Tindaro Bongiovanni, Player Health & Performance, Palermo, Italy, Email: t.bongiovanni@palermofc.com

Introduction

Sports participation entails a considerable risk of injury for both elite and recreational athletes,[1] and injury reduction, control, and prevention are important goals for clinicians, researchers, athletes, and the active population.[2] The prevention of sports injuries is a primary focus for health promotion agencies and sporting bodies across all levels of participation, from elite athletes to community sports, to active recreational pursuits.[3]

According to the "four-step sequence of prevention" proposed by Van Mechelen in 1992,[4] and the "Translating Research into Injury Prevention Practice" framework proposed by Finch in 2006,[5] injury and illness surveillance provides essential data to drive the development and implementation of prevention strategies in sport. Furthermore, the International Olympic Committee (IOC) stated that injury and illness surveillance and epidemiological studies are fundamental tools to protect the health of the athletes and carefully designed surveillance programs including accurate data capture and careful analysis of data are building blocks for sports injury and illness prevention programs.[6]

Injury and illness data collected in a routine and systematic manner, when coupled with appropriate exposure data, can enable estimation of health problem incidence in both experimental and observational studies and can be used to monitor temporal and spatial trends in health problem rates and evaluate the success of prevention strategies.[7] Standardized data collection is, therefore, crucial to underpin the provision of safe opportunities for all those who participate in sports.[3]

Although the type of data collected in an injury and illness surveillance depends on the needs of its end-users (e.g., clinicians and epidemiologists), it is recommended that a core set of variables are collected, regardless of the surveillance's purposes,[8] and that a standardized approach is used.

This narrative review aims to clarify the key concepts and definitions of injury and illness surveillance in sports and reduce the gap between scientific literature and clinical practice providing clinicians with a practical and useful format to record, track, and analyse data on health problems.

Methods

Research team

To support robust and relevant results, the research team included authors with expertise in evidence synthesis, research methodology, sports science, and sports medicine.

Review question

We formulated the PICO question: (((sport (Title/Abstract) OR sports (Title/Abstract)) AND (injury (Title/Abstract) OR injuries (Title/Abstract))) AND (illness (Title/Abstract) OR illnesses (Title/Abstract))) AND (surveillance (Title/Abstract)), which guided our narrative review and served as a framework to identify relevant studies, analyse their findings, and synthesize the available evidence.

Eligibility criteria

We included in this narrative review studies investigating how to record and report data on injuries and illnesses in sports, studies exploring definitional issues and key concepts of, as well as consensus statement on, injury and illness surveillance. Finally, studies assessing the impact and the effectiveness of injury and illness surveillance procedures in sports injury prevention and studies exploring or comparing different modalities or approaches related to injury and illness surveillance in sports were included. Studies not published in peer-reviewed journals, not published in the English language, and not conducted within appropriate sports contexts were excluded from this narrative review.

Search strategy

Research on MEDLINE was performed through the PubMed interface to identify articles on the topic. The search strategy, which included all identified keywords, was adapted for use in Scopus and Embase databases. In addition, grey literature (e.g., Google Scholar, and direct research of experts in this topic) and reference lists of all relevant studies were also searched. The research commenced on the 5th of June 2023 and did not set any date limitation. Two authors independently reviewed the articles based on their titles and abstracts. Any conflict or discrepancy between the reviewers' decisions was resolved by a third author. The same procedure was used for the full-text assessment.

Results

The search strategy led to the identification of 216 articles to which 8 articles were added from grey literature. After removing duplicates and screening the title and abstract, we excluded 161 articles and 63 articles were assessed for eligibility on full text from which 2 articles were excluded, for a result of 61 papers included in this narrative review (**Fig. 1**).

Discussion

Why do clinicians working in sports need to perform injury and illness surveillance?

Although regular physical activity reduces the risk of premature mortality,[9, 10] it also entails a considerable risk for health problems for elite, as well as recreational, athletes.[1] Sports bodies and medical teams have a duty of care to their participants, including maximizing safety and mitigating health problems risk across all levels of participation.[11] To be most effective, implementation of prevention programs needs to target specific priorities within each sport; therefore sport-specific information about the nature, type, cause and incidence of health problems is needed to set these priorities.[7] One of the first authors driving the research on sports health problems prevention was van Mechelen[4] who in 1987 and 1992 proposed a conceptual model made by four steps **(Fig. 2)** called "the sequence of injury prevention." The description of the magnitude of the problem, known as injury and illness surveillance, represents the first step of this sequence and states that clinicians aiming to implement health problem prevention strategies within their sport setting must start from the performance of a detailed injury and illness surveillance.

What is a sports injury and illness surveillance?

Injury and illness surveillance has been defined as the standardized, routine, and ongoing process of collecting data relating to in-

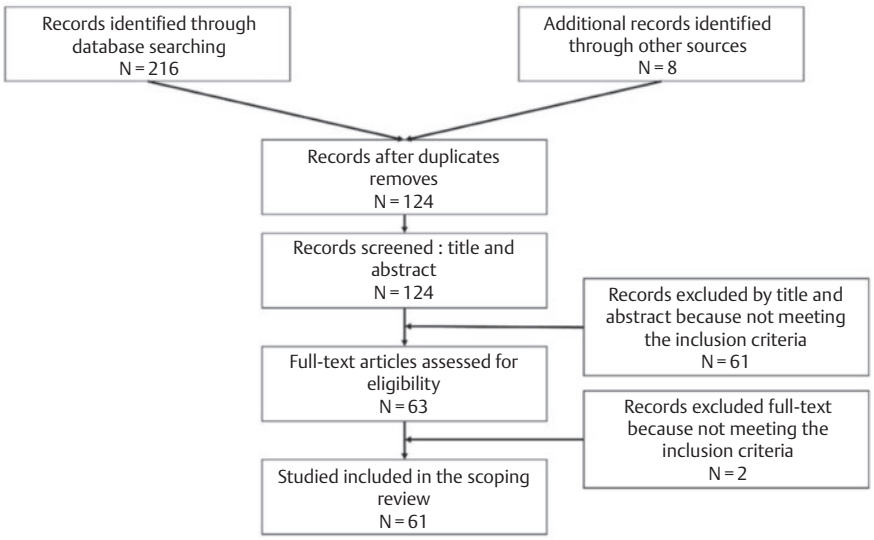

Fig. 1 The search strategy diagram that led to the inclusion of 61 papers in our narrative review.

Fig. 2 The sequence of injury prevention (adapted by van Mechelen et al. 1992[4]): the first and the fourth steps of the sequence are represented by the conduction of injury surveillance; also, the second step looking for injury mechanism and aetiology can be supported by the conduction of injury surveillance procedures.

jury and illness occurrence and its causes.[7] From a systematic review of 2015 conducted by Ekegren et al.[12] on 15 sports injury and illness surveillance systems, publications concerning data quality were identified for seven systems, highlighting the lack of standardization on data collection methods. Furthermore, standard methods to record and report the magnitude of injuries and illnesses are needed to facilitate the comparison of data between studies from different sports and levels of performance.[13] Several consensus statements aiming to standardize the methodology and reporting of epidemiological studies were published during the last 20 years for both team and individual sports. To encourage consistency in the definitions and methods used and to enable data across studies to be compared, research teams have published several consensus papers most of those addressing specific sports such as cricket,[14] football,[15, 16] rugby union,[17] rugby league,[18] aquatic sports,[19] tennis,[20] athletics,[21] and horse racing.[22] In 2020, the IOC published a consensus on definitions of Injury and Illness Surveillance System[6] stating an updated set of recommendations for sports injury and illness studies and including a new "Strengthening the Reporting of Observational Studies in Epidemiology" (STROBE) checklist extension.[23] The expert panel updated recommendations on the methods for recording and reporting epidemiological data on injury and illness in sports in a sports-generic consensus statement.

How do clinicians recognize a health problem?

In 1946, the World Health Organization defined health as a "state of complete physical, mental and social well-being" and not merely the absence of a disease or infirmity.[24] Clarsen et al. extended this definition for sport, introducing the concept of acute and overuse injuries and defining 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 sought medical attention." This constitutes an umbrella term that includes, but is not limited to, injury and illness.[25]

The first author to understand the importance of a universally applicable definition for sports injury was van Mechelen, who in 1992 analysed the literature finding different definitions as "an injury sustained during sporting activities for which an insurance claim is submitted"[4] and "injuries treated at a hospital casualty or other medical department."[26] The most extensive definition was that proposed by the Council of Europe, in which a sports injury was defined as "any injury resulting from participation in sport with one or more of the following consequences: a reduction in the amount or level of sports activity, a need for [medical] advice or treatment, and adverse social or economic effects."[27] However, van Mechelen concluded that to avoid the "tip of the iceberg" phenomenon, an unambiguous, universally applicable definition of sports injuries was necessary, and he finally described sport injuries as a collective name for all types of damage that can occur in relation to sport activities.[4] In 2006, Fuller et al. in a consensus statement on injury definition and data collection in football[15] defined an injury as "any physical complaint sustained by a player that results from a match or a training: an injury resulting in a player receiving medical assessment by a qualified medical practitioner was referred as a 'medical attention' injury, while an injury resulting in a player being unable to take a full part in future training or match was referred as a 'time loss' injury. The term 'future' refers to any time after the onset of the injury, including the day of the injury" (**Fig. 3**).

This definition by Fuller et al. has been adopted by the IOC in 2008[28] and finally updated in the last consensus in 2020,[6] in which to remain aligned with classic epidemiology studies, who viewed

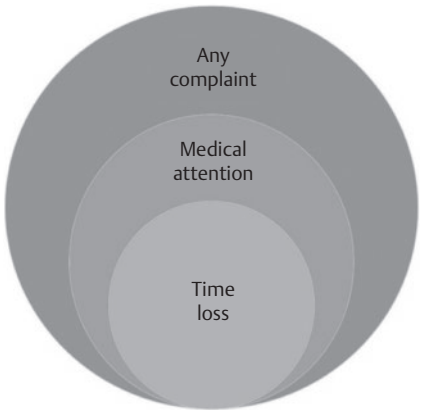

Fig. 3 Sports injuries classification: any complaint includes all the problems reported by athletes; medical attention problems include those problems requiring for medical assessment; time-loss injuries include those problems taking the athletes out for following training sessions or competitions.

a health problem as the result of interaction between agent, host, and environment[29] and introduced the term "kinetic energy" as the agent for an injury: "injury is a tissue damage or other derangement of normal physical function due to participation in sports resulting from rapid or repetitive transfer of kinetic energy" with the rapid or repetitive terms differentiating between acute and gradual-onset (overuse) injuries. Also, in the same statement, illness has been taken into consideration and defined as "a complaint or disorder experienced by an athlete, not related to an injury, including health-related problems in physical, mental, or social well-being, or loss of vital elements."

Which data on health problems do clinicians need to collect?

A core set of variables for injury and illness surveillance is needed.

Where is the health problem localized? Body area or medical system

One of the main goals of surveillance studies is to classify and group injuries and illnesses so that trends can be monitored over time, and incidence or prevalence compared between groups.[30] Different injury and illness classification systems have been developed over time: the International Classification of Diseases (ICD) system, represents an important international standard, but it has the limitation of missing many important issues related to sports medicine.[31] In the early 1990s, in Canada and Australia, two alternative diagnostic coding systems were developed specifically for Sports Medicine, being today the widely used systems in sports injury surveillance.[6] These diagnostic codes are the Sport Medicine Diagnostic Coding System (SMDCS) with 750 diagnoses[2] and the Orchard Sports Injury and Illness Classification System (OSIICS) with around 1,600 diagnoses.[32] Both systems are based on initial codes representing the body area (the medical system for illnesses) and further codes identifying the injury type and pathology (the aetiology for illnesses). Regarding injuries, the body areas have been defined as either joints or segments (e.g., hip and thigh) with some exceptions related to areas such as the hip and groyne where a joint is considered together with a segment area. The tissue type refers to the kind of tissue that suffers the injury (e.g., bone and muscle), and the pathology type refers to the specific pathology that each tissue type could suffer (e.g., bone contusion or fracture). Finally, the SMDCS and the OSIICS also allow clinicians to define specific diagnoses. When athletes or non-medical staff report injuries, to avoid mistakes in data collection, they must only report the body area.[6] Regarding illnesses, clinicians must record the system suffering the illness and the aetiology. When athletes self-report illnesses, they must only record symptoms rather than attempt to report a diagnosis.[33] Specific descriptions of cluster symptoms for self-report of illnesses have been provided by the IOC consensus.[6] To facilitate reporting based on diagnostic codes, a document providing a full list of revised SMDCS and OSIICS codes, along with a translation between both systems and the ICD system, has been published by Orchard in 2020.[34]

When did the health problem happen? The relationship to sports activity

According to the IOC consensus statement, a health problem may result from participation in competition or sport-specific training, related to competition or training but not during those sessions, or from activities that are not at all related to participation in sports.[6] This variable is only suitable for injuries as it is difficult to define for illnesses. Clinicians must record this feature as "direct relationship," "indirect relationship," or "no relationship" with sports activity, respectively. When related to sports activity, clinicians must specify if this was a competition or training (details in the exposure chapter 4.4.7). Finally, it could be useful to add information about the moment of onset (e.g., minute), the part (e.g., first or second half) the athlete suffered the injury or for team sports, and the time distance to the previous or following competition (e.g., competition day +2/−5).

How did the health problem begin? The mode of onset

Important information to capture from an injury and illness surveillance aspect is the mode of onset of health problems. Traditionally, health problems were classified into acute and overuse, resulting from a specific and identifiable event (e.g., a direct blow to the Quadriceps during a match), or not related to a sudden and identifiable onset event (e.g., tendinopathy by repetitive movement) respectively. However, since the terms "acute" and "overuse" are used inconsistently in literature[35] and most of the injury surveillance systems do not define "acute or overuse injuries,"[36] IOC suggested to consider the "kinetic energy" element to classify the mode of onset: injuries may then result from an instantaneous exchange of kinetic energy, from a gradual accumulation of kinetic energy over time, or from a combination of both mechanisms. According to this, to better describe the onset of an injury, clinicians must record the mode of onset as "sudden-onset," "gradual-onset," or "mixed," respectively. Despite this suggestion, since it requires clinicians' interpretation, the mode of onset remains a subjective information, and a reliable framework to define has still not been developed.

In relation to illnesses, although IOC suggested to specify if an illness is associated with a specific precipitating event or with a progressive pathway that cannot be linked to a specific precipitating event, in their proposed report format for illnesses, the feature "mode of onset" is not present, and we think this variable should not be used for illnesses.

How did the health problem happen? The mechanism

This variable is only used for injuries. Six different types of injury mechanisms have been advised,[6] one of which is related to gradual-onset injuries and the other five are related to sudden-onset injuries. When reporting injury mechanisms, clinicians must consider two main categories: contact and non-contact mechanisms. Contact injuries are then classified into "direct contact mechanisms," when the kinetic energy is applied directly to the injured area (e.g., an opponent athlete kicking another athlete to the ankle), or "indirect contact mechanisms," when a contact with an opponent or an object is still the cause of injury, but the kinetic energy is not applied directly to the injured area (e.g., an opponent athlete push another athlete which crashes into the advertisement panels). Non-contact mechanism is injuries without any contact with external sources. A detailed explanation of the mechanism would help clinicians to better understand the causes of injuries and then address risk factors. A list of sources of contact (e.g., objects and opponent) and actions (e.g., sprinting and cutting) potentially leading to contact or non-contact injury, respectively, must be provided by sport-specific injury surveillance consensus as done for soccer.[16] Notes on the specific action for non-contact mechanisms and on the source of contact for contact mechanism injuries could be provided by clinicians when the mechanism details are not provided.

How many health problems did an athlete suffer during the monitored period? Multiple events

During a surveillance period (e.g., one season), there is the chance that athletes sustain more than only one health problem. When more than one problem is experienced, the terms "index injury (or illness)" for the first problem and "subsequent injury (or illness)" for the following problems are used to differentiate those in a time-ordered sequence.[37] When the same body part or medical system is repeatedly involved, the term "recurrent" must be used.[38]

Health problems are often recurrent and there is a wide recognition that a subsequent problem can be strongly related to or influenced by a previous one.[39] It is important to know whether a health problem is related to a previous one because it could provide insight into the aetiological factors that underpin subsequent problems.[37] A first definition of recurrent injuries was made by Orchard in 2005, who defined a recurrent injury as an injury to the same body part and of the same type as the index injury that previously occurred in the same season, from which the player had recovered and returned to full participation.[40] An extension of this definition was added by Fuller in 2006, who gave timing to recurrent injuries, suggesting that if the new injury occurs within 2 months of a player's return to full participation, it is called "early recurrence," if it occurs between 2 and 12 months after a player's return to full participation, it is called "late recurrence," and finally, if it occurs more than 12 months after a player's return to full participation, it is called "delayed recurrence."[15] This definition has been accepted and used by different authors,[19–22] but despite similarities between different sports, inconsistencies in the reporting of recurrent injuries remained.[41]

Subsequent health problems are statistically related to prior injuries even when the two injuries are clinically distinct[30,38] and it is important to categorize those in the right way. Although recent frameworks incorporating extensive criteria to categorize subsequent injuries and illnesses have been presented, as the SIC 1.0 and 2.0 proposed by Finch and Toohey, respectively,[30,42,43] the use of these criteria requires high skills by clinicians and could increase the risk for data errors.[44] The categorization of Hamilton of 2011 provides a useful framework to classify subsequent injuries in sport[38] and it has been adopted and slightly adapted by the IOC 2020 consensus (**Fig. 4**). In this categorization, an "index injury (or illness)" is the first recorded injury (or illness). A "subsequent injury" is any injury occurring after the index injury in the studied period. If the subsequent injury affects a different body area, it must be classified as a "subsequent new injury." If it affects the same body area as the index injury but a different tissue type, it must be classified as "subsequent local injury." If it affects the same body area and the same tissue type as the index injury, it must be classified as "recurrent injury" which if happens after the athlete was healed and fully recovered it must be classified as "reinjury," while if it happens before the athlete was healed and fully recovered, it must be classified as "exacerbation."

When referring to illnesses, a "subsequent illness" is any illness occurring after the index illness in the studied period. If it affects a different system, it must be classified as "subsequent new illness." If it affects the same system as the index illness but with a different aetiology, it must be classified as "subsequent local illness." If it happens to the same system and with the same aetiology as the index illness, it must be classified as "recurrent illness," which if happens after the athlete was healed and fully recovered, it must be classified as "repeated illness," while if it happens before the athlete was healed and fully recovered, it must be classified as "exacerbation."

Athletes can be defined as healed and fully recovered from an injury or an illness when they are fully available for training and/or competition. Although, in the first definition of Fuller, recurrences were also classified into early, late, and delayed recurrences, this information is not necessary, but the recording of the exact date of onset of each health problem is essential for the sequence to be clear.

How long the athlete has been out from training and competition because of a health problem? The time loss

"Time loss" is the number of days an athlete is unavailable for training and competition due to a health problem. When counting time loss, clinicians must start from the day after the onset of the injury (representing day 1) till the day before the athlete returns to sport. This means that if an athlete, due to a health problem, does not complete a training session or a competition in the morning but is able to participate on the same day (e.g., afternoon training

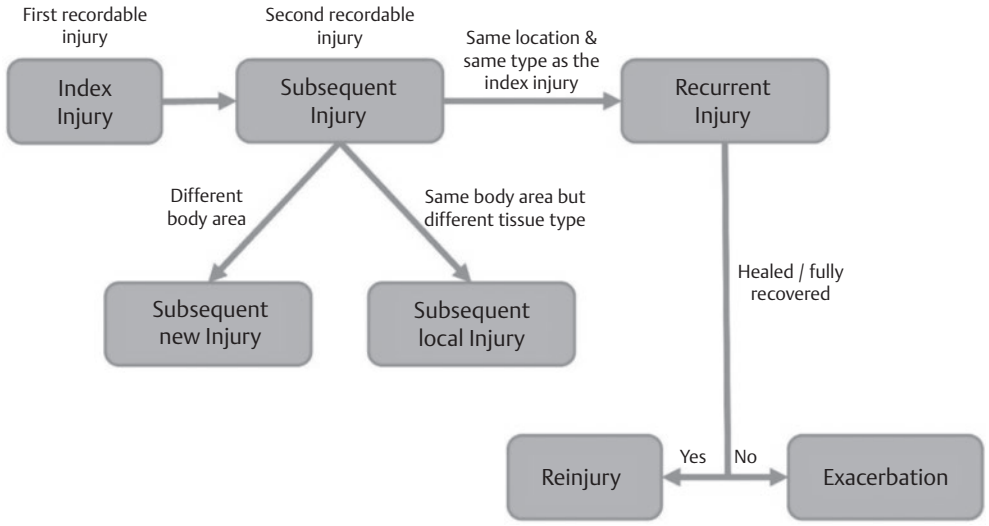

Fig. 4 Framework to categorize subsequent injuries in sport (adapted by Hamilton et al. 2011[38]) and differentiate subsequent injuries from recurrent injuries (or illnesses) which are as well differentiated in reinjuries and exacerbations based respectively on the fact the athlete has returned to sport or not.

or same-day competition) or on the following day, this health problem must be counted as zero days of time loss.

Tricky situations for time-loss calculation exist as when the time loss is "delayed" and "intermittent," or when the clinician do not dispose of clear information regarding the return to the sport of the injured/ill athlete. In some cases, time loss does not follow immediately the health problem and is "delayed," for example, an athlete suffering a health problem on Monday, who trains on Tuesday, competes on Wednesday, and then stops to train starting from Thursday. In this case, the time loss does not start from the day of onset of the health problem (Monday in the example), but it must be counted from the day the athlete stops participating in training or competition (Thursday in this example).

An example of "intermittent" time loss is an athlete asking for medical attention on Monday, who attends training on Monday, Tuesday, and Thursday but misses training on Wednesday and Friday. In this case, time loss must only consider Wednesday and Friday and counted as 2 days. This case is typical for overuse injuries or chronic conditions.

If an athlete recovers from health problems during periods with no planned training or competition (e.g., during the off-season break), the ending of the time loss must be recorded as the day when the athlete normally would have been ready for full training and competition.

If an athlete leaves an event with a health problem and information on the return to full training or competition is not available, clinicians must estimate the expected return to full training and competition or record the last day they have seen the athlete with the ongoing health problem. This information must be clearly labelled as "estimated severity" or "right-censored injury duration" respectively.[6]

If, during a single health problem event, an athlete suffers multiple health problems, clinicians must record each problem separately and time loss must only consider the problem leading to the longest time loss.

Which data on exposure to sports participation do clinicians need to collect? Training and competition

Alongside the recording of injuries and illnesses events, clinicians must capture the exposure of athletes to sports participation in training and competitions.[45] Generally, exposure is quantified as the time during which athletes are at risk of sustaining a health problem and so as the number of training sessions or competitions but sometimes could be useful to also report sport-specific parameters (e.g., covered distance in a game) or the number of specific events (e.g., jumps and throws). Related to team-sports exposure should be recorded individually for each player rather than using the team's average.[6]

Competition has been defined as an "organised scheduled play between opposing athletes or teams, or as athlete competing against time and/or to obtain a score judged or measured."[6] Simulation of competition such as friendly games or sparring sessions must be recorded as training. Some activities as warm up or cool down, even when related to competition, must be recorded as training, and injuries occurring during these activities must be considered training injuries. Training has been defined as "physical activity performed by an athlete aiming to maintaining or improving his/her skills, physical condition, and/or sport performance."[6] Also, clinicians could record different subcategories of training separately as "sport-specific training" (e.g., tactical or technical session supervised by a coach), "strength and conditioning training" (e.g., session only composed by resistance or conditioning training), or "other training session" made by different activities other than sport-specific or strength and conditioning (e.g., recovery session and rehabilitation). Despite IOC suggesting this as a subcategory of training, in our opinion, rehabilitation sessions should be con-

sidered an independent category, as suggested by football-specific extension,[16] and should be excluded from training exposure as such sessions are part of the duration of the injury or illness. Since training sessions are often mixed, when containing sport-specific training, a session must be recorded as such, even if it includes other tasks. Finally, related to exposure in team sports, distinguishing the subcategories "team training" and "individual training" may be necessary: e.g., in football-specific extension of IOC consensus, authors only suggested "football-specific training," but this subcategory may refer to both team or individual training. Athletes who perform sport-specific individual training should be registered as "sport-specific individual sessions" if they practice sport-specific tasks or "strength and conditioning" if they only practice strength or conditioning tasks; athletes who train with the team but perform partial sessions (e.g., an athlete only attending a part of the team-training) or modified sessions (e.g., an athlete attending a part of the training with the team and another part individually) should be registered, respectively, as "team training - partial" or "team training - modified." Future consensus should take into consideration this topic.

When referring to illnesses, since athletes are also at risk of developing illnesses when not participating in sports, exposure must consider the time athletes are under surveillance (days) rather than the times they are engaged in competition or training.

A practical template

Recommended categories of body areas of injuries, tissue type and pathology type for injuries, aetiology for illnesses, mechanisms of injuries, and templates for data collection, alongside an example of a filled template for a typical injury in soccer, have been prepared by the authors and are shown in supplementary materials (see Supplementary **Tables S1–S9**, available in the online version only).

How could clinicians practically collect data on athletes' health problems and exposure?

Data collection methods can have a great impact on the outcome of a sports injury and illness surveillance.[7,46,47] According to the guidelines for injury surveillance published in 2001 by WHO, surveillance must take into consideration the quality of data collection (e.g., objectivity and reliability) and the education of clinicians through the sharing of statements on definitions, data collection procedures, and guidance documents. Finally, methodological issues such as the completeness of reports should be analysed and addressed during the period of surveillance.[28,48–49]

Regarding data collection, despite the pen-and-paper approach being easy to implement,[50] it seems that electronic data capture reduces the time for the duplication of data entry[50] and entry errors.[51] Also, electronic data captures have potential long-term cost-effectiveness[51] and web-based solutions allow instant and remote data sharing and integration of injuries data with other data related to performance, load, sleep, etc. Those kinds of systems have been successfully used in several professional elite leagues and organizations. However, particular attention must be directed to the security of data stored on cloud-based systems and other electronic repositories, and researchers must adhere to the data protection regulations applicable to their context, such as the General Data Protection Regulation in Europe.[6] Finally, despite the benefits of electronic data capture, we need to consider potential variability in user proficiency, data integrity, and other bias factors. It would be important to educate users on data entry as well as to limit the data entry opportunity to medical practitioners, also creating filters to reduce mistakes. Also, when interpreting data that are self-reported by athletes, as in the surveillance of overuse injuries by OSTRC, researchers and clinicians must avoid athletes making self-diagnoses and limiting their data entry to indicate the body area in pain (for injuries) and the symptoms suffered (for illnesses).

How can clinicians express the risk of health problems? Analysis and reporting of injury surveillance data

Since the goal of an injury and illness surveillance study is to understand the impact of health problems on a sport-specific population to plan prevention strategies, it is important that surveillance reports are clear and useful. When reporting data, clinicians need to consider measures to express the risk, indicate athletes' availability, show differences in risks between different populations, and finally consider overuse injuries, often not included in surveillance studies.

The most frequently used measure to express injury and illness risk in sports is the rate at which those happen. "Rate" is usually reported as the number of cases divided by the population at risk.[52] Two fundamental measures to express rate are prevalence and incidence. "Prevalence" answers the question "how many?" and refers to the number of existing cases of a health problem divided by the total population at risk at a given time point. It is an appropriate measure to show the risk of gradual-onset health problems[53] and when repeated over time, it allows comparison at different stages of the season. "Incidence" answers the question "how often do new cases occur?" and refers to the number of new health problems in the population at risk during a defined period. It is an appropriate measure to show the risk of sudden-onset health problems. Incidence measures in sports are generally reported as a number of cases per 1000 hours of exposure to sports participation. When exposure is not available in detail, injury incidence could be reported as the number of injuries per 365 days or per the length of the surveillance. However, reporting incidence this way does not express relative risk and does not allow comparisons. An interesting measure of incidence is the injury rate per event (e.g., for throwing), providing information about how likely a specific event can result in an injury.[1,54]

Another important parameter to consider when reporting data on surveillance studies is the "severity." Different definitions of severity for health problems exist, but the most widely used in sports is "time loss." Based on duration in days, the severity of health problems has been classified by IOC in four time ranges: 0 days, 1–7 days, 8–28 days, and more than 28 days. However, sport-specific consensus suggested different ranges, as in the consensus for injury surveillance in soccer.[55]

Although time loss is the most widely used and accepted way to measure severity, it has the limitation of not addressing very well overuse injuries (e.g., tendinopathies) and recurrent chronic illnesses (e.g., inflammatory arthritis),[53] for which clinicians could use patient-reported-outcome-measures (PROMs) in describing

the most severe health problems' clinical outcomes leading to retirement from sport, permanent disability, or death, since these events miss a date for the return to full participation, for which clinicians could use the terms "catastrophic event" for injuries resulting in permanent disability, "life-threatening non-injury events" for threatening health problems as sports-related sudden cardiac arrest,[56] or "fatality" for death related to training or competition.[57]

Bahr et al. in 2017 proposed to introduce a measure called "burden," representing the cross-product of severity and incidence of a health problem.[58] The burden is an interesting measure to express the overall impact of health problems in a population, allowing comparison between different health problems and the understanding of which impacts a specific sports population the most. The burden of health problems can be shown through a "risk matrix" reporting incidence and severity together. In team sports, the burden has been reported as the number of days of time loss (sum of the severity of health problems) either per 1000 hours of player's exposure[59] or per 1000 athletes' days,[6] for each specific health problem.

How could clinicians survey gradual-onset injuries?

Gradual-onset injuries are often not surveyed by injury surveillance systems until the moment the athlete is forced out from training and competition by non-sustainable symptoms, with the same happening for illnesses with minor symptoms. However, overuse injuries can have substantial consequences for athletes, causing pain, reduced physical performance, and reduced sports participation, also representing a common cause of premature retirement from sports[60,61] and causing symptoms for long periods after sporting careers are finished.[62] To address this potentially relevant limitation, surveillance procedures could be enriched using PROMs. Different PROMs exist to monitor body-area or pathology-specific gradual-onset health problems. A frequently used tool is the OSTRC Questionnaire on overuse injuries developed by Clarsen et al. in 2014 and then updated in 2020 to address the severity of health problems in sports.[25,63] The main limitation of PROMs is that captured information is gathered directly from the athletes rather than by health professionals.

Reporting athletes' availability and multiple events

A relevant measure that clinicians can extract from surveillance studies to show the impact of injuries and illness on the sport participation, is athlete availability. Details on reasons for unavailability and longitudinal analysis of health problems sequence[64] help clinicians to understand the relationships between index health problems and subsequent ones.

Reporting sport population characteristics

As a minimum, when reporting injury and illness surveillance data, clinicians must indicate information, such as age, sex, and level of competition of the sport population in consideration. However, sport-specific consensus is needed to provide detailed definitions of competition levels.

Conclusion

Injury and illness surveillance is the first step in the implementation of health problem prevention programs. The goal of surveillance is to enumerate the extent of athletes' health problems related to sport, for which the continuous tracking of exposure, injuries, and illnesses through accurate data capture and careful analysis of data are building blocks. When collecting data to perform injury and illness surveillance a core set of variables is needed to be recorded: in relation to injury location (body area), tissue type and pathology type must be collected alongside the relationship to the sport activity, the mode of onset, and the injury mechanism. Finally, information to know if the injury is a new or a subsequent injury and the duration of the time loss (severity) needs to be captured. In relation to illnesses, details on organ system and aetiology, time loss, and information to understand if it is a new or a subsequent illness need to be acquired. Clinicians implementing sport injury and illness surveillance must ensure that data collection follows mandatory standards and timing and provides clear reports. The use of in-cloud software solutions must be preferred to pen-and-paper solutions due to cost-effectiveness, instant data sharing, and reduced data entry errors.

Author affiliations

1 Player Health & Performance, Manchester City Football Club Ltd, Manchester, United Kingdom of Great Britain and Northern Ireland
2 Player Health & Performance, Palermo, Italy
3 School of Pharmacy, Physics Unit, University of Camerino, Camerino, Italy
4 Department of Computer Science, Università degli Studi di Pisa, Pisa, Italy
5 Athletic Èlite track and field, Italy
6 Athletic Physiotherapy, Milano, Italy
7 Department of Sports Medicine, Norwegian School of Sports Sciences, Oslo, Norway

Statements and additional information

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Table 1. Recommended categories of body areas for injuries

Body Areas	**OSIICS**	**SMDCS**	**Notes**
Head	H	HE	Includes face, brain, eyes, ears, teeth
Neck	N	NE	Includes cervical spine, larynx, major vessels
Shoulder	S	SH	Includes clavicle, scapula, biceps tendon origin, rotator cuff
Upper arm	U	AR	
Elbow	E	EL	Includes insertional biceps and triceps tendon
Forearm	R	FA	Includes non-articular radial and ulnar injuries
Wrist	W	WR	
Hand	P	HA	Includes thumb and fingers
Chest	C	CH	Includes chest organs, breast
Thoracic Spine	D	TS	Includes costovertebral joints
Lumbosacral	L	LS	Includes sacroiliac joints, coccyx, buttocks
Abdomen	OSIICS	AB	Includes abdominal organs
Hip/Groin	G	HI	Includes pubic symphysis, proximal adductors, iliopsoas
Thigh	T	TH	Including mid-distal adductors
Knee	K	KN	

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Lower leg	Q	LE	Includes non-articular fibular injuries, calf, Achilles tendon
Ankle	A	AN	Includes syndesmosis, talocrural and subtalar joints
Foot	F	FO	Includes hallux and toes
Unspecified	Z	OO	
Multiple (single injury crossing 2 or more areas)	X	OO	

Table 2. Recommended categories of tissue type and pathology type for injuries

Tissue Type	**Pathology Type**	**OSIICS**	**SMDCS**	**Notes**
Muscle/ tendon	Muscle injury	M	10.07-10.09	Includes strain, tear, rupture, intramuscular tendon
	Muscle contusion	H	10.24	
	Muscle compartment syndrome	Y	10.36	
	Tendinopathy	T	10.28-10.29	Includes paratenon, related bursa, fasciopathy, tendon subluxation, partial tear, enthesopathy
	Tendon Rupture	R	10.09	
Nervous	Brain/spinal cord injury	N	20.4	Includes concussion

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	Peripheral nerve injury	N	20.39, 20.41-20.42	Includes neuroma
Bone	Fracture	F	30.13-30.16, 30.19	Includes avulsion fracture, teeth
	Bone stress injury	S	30.18,30.32	Include bone marrow oedema, stress fracture, periostitis
	Bone contusion	J	30.24	
	Avascular necrosis	E	30.35	
	Physis injury	G	30.2	Include apophysis
Cartilage/ synovium/ bursa	Cartilage injury	C	40.17, 40.21, 40.37	Includes meniscal, labral, articular cartilage, osteochondral injuries
	Arthritis	A	40.33-40.34	
	Synovitis/ capsulitis	Q	40.22,40.34	Includes joint impingement
	Bursitis	B	40.31	Includes calcific bursitis, traumatic bursitis
Ligament/ joint capsule	Joint sprain (ligament tear or acute instability episode)	L or D	50.01- 50.11	Includes partial and complete tears to nonspecific ligaments and joint capsule; includes joint dislocations/subluxations
	Chronic instability	U	50.12	
Superficial tissues/skin	Contusion (superficial)	V	60.24	Contusion, bruise, vascular damage

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	Laceration	K	60.25	
	Abrasion	I	60.26-60.27	
Vessels	Vascular trauma	V	70.45	
Stump	Stump injury	W	91.44	In amputees
Internal organs	Organ trauma	O	80.46	Excluding concussions
Nonspecific	Injury without tissue type specified	P or Z	00.00, 00.23, 00.38, 00.42	

4

5 Table 3. Recommended categories of medical systems for illnesses

Organ System	**OSIICS**	**SMDCS**	**Notes**
Cardiovascular	MC	CV	
Dermatological	MD	DE	
Dental	MT	DT	
Endocrinological	MY	EN	
Gastrointestinal	MG	GI	
Genitourinary	MU	GU	Includes renal, obstetrical, gynecological
Haematological	MH	BL	
Musculoskeletal	MR	MS	Includes rheumatological conditions
Neurological	MN	NS	

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Ophthalmological	MO	OP	
Otological	ME	OT	Ear only
Psychiatric/psychological	MS	PS	
Respiratory	MP	RE	Includes nose and throat
Thermoregulatory	MA	TR	
Multiple systems	MX	MO	
Unknown or not specified	MZ	UO	

Table 4. Recommended categories of aetiology for illnesses.

Aetiology	**OSIICS**	**SMDCS**	**Notes**
Allergic	MxA	71	
Environmental (exercise related)	MxE	72	Heat illness, hypothermia, hyponatremia, dehydration
Environmental (non-exercise)	MxS	73	Sleep/wake, sunburn
Immunological/ inflammatory	MxY	74	
Infection	MxI	75	
Neoplasm	MxB	76	
Metabolic/ nutritional	MxN	77	
Thrombotic/ haemorrhagic	MxV	78	
Degenerative or chronic condition	MxC	79	Chronic acquired conditions

Developmental anomaly	MxJ	80	Includes congenital conditions
Drug-related/ poisoning	MxD	81	Includes pharmaceutical, illicit
Multiple	MxX	82	
Unknown or not specified	MxZ	83	

Table 5. Recommended relationship of a health problem to sport activity.

Relationship	**Example**
Direct	Athlete sustaining an injury during a match
Indirect	Athlete sustaining an injury in the changing room
Not at all related to participation in sports	Athlete sustaining an injury in a car crash

Table 6: Recommended modes of onset for injuries

Onset	**Example**
Sudden-onset after acute trauma	An athlete sustaining a muscle injury during a sprint
Mixed	An athlete sustaining a metatarsal fracture on a specific movement, but with pre-existing bone stress on the same area
Gradual-onset	An athlete experiences a gradual increase in patellar tendon pain during a training camp

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16 Table 7: Recommended mechanisms of injuries.

Injury	**Type of contact**	**Example**
Non-contact	No presence of contact with the athlete	A player sustaining an ACL rupture during a pivoting movement
Direct contact	With another athlete	A player sustaining an ACL rupture from a tackle from an opponent
Direct contact	With an object	A player sustaining a concussion from being hit in the face by the ball
Indirect contact	Through another athlete	A player sustaining an ACL rupture landing after being pushed by an opponent
Indirect contact	Through an object	A player sustaining a concussion on the floor after running on the advertisement panels and loosing balance

17

18 Table 8: A proposal for a model for data collection on injuries and illnesses in sport

Opening of a Report for Injury or Illness					**N°**
Sport	League	Team	Athlete id. number	Date of onset	Injury or illness
For Injury					
Injured body area	Tissue Type	Pathology Type		OSIICS code	SMDCS code
Relationship to Sport Activity	Competition or training	Mode of onset	Injury mechanism		Index, subsequent, recurrent
Time-loss	Notes (please indicate the time of the injury)				
For Illness					

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Organ system		Aetiology	OSIICS code	SMDCS code
Time-loss	New, subsequent, recurrent	Notes		

Table 9: A practical example for data collection for an injury.

Opening of a Report for Injury or Illness					**N°1**
Sport	League	Team	Athlete id. number	Date of onset	Injury or illness
Soccer	One	A	I	DD/MM/YYYY	Injury
For Injury					
Injured body area	Tissue Type	Pathology Type		OSIICS code	SMDCS code
Posterior Thigh	Muscle/Tendon	Muscle lesion			
Relationship to Sport Activity	Competition or training	Mode of onset	Injury mechanism		Index, subsequent, recurrent
Direct	Competition	Sudden-onset	Sprinting		Index
Time-loss	Notes (please indicate the time of the injury)				
Yes					
For Illness					
Organ system		Aetiology		OSIICS code	SMDCS code
Time-loss	New, subsequent, recurrent	Notes			

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