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CHAPTER 2

MEASURING SPORTS INJURIES ON THE PITCH: A GUIDE TO USE IN PRACTICE

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ABSTRACT

Sport participation is a major ally for the promotion of physical activity. However, sports injuries are an important adverse effect of sports participation and should be monitored in sporting populations. The purpose of this paper was to review the basic concepts of injury monitoring and discuss the implementation of these concepts in practice. The aspects discussed are: (1) sports injury definition; (2) classification of sports injuries; (3) population at risk, prevalence, and incidence; (4) severity measures; (5) economic costs; (6) systems developed to monitor sports injuries; and (7) online technology. Only with reliable monitoring systems applied in a continuous and long-term manner will it be possible to identify the burden of injuries, to identify the possible cases at an early stage, to implement early interventions, and to generate data for sports injuries prevention. The implementation of sports injuries monitoring systems in practice is strongly recommended.

INTRODUCTION

The pandemic of physical inactivity is a major public health problem of the 21st century.¹⁻³ Physical inactivity was responsible for 6% to 10% of non-communicable diseases in 2008 and it is a leading risk factor for mortality,⁴ accounting for 5.3 million deaths in the same year.⁵ Initiatives have been proposed worldwide in order to promote physical activity.^{2,6} In Brazil, this is also a matter of concern since the prevalence of physical inactivity in adults is estimated to be around 40%.⁷ One of the largest initiatives to promote physical activity in Brazil is the *Academia da Saúde* (Health Gym) project supported by the Brazilian Ministry of Health.⁸⁻¹⁰ This program is aimed at reducing the barriers to the access of physical activity and to decrease the risk of non-communicable diseases by building 4,000 community gyms.^{8,9}

Sports participation may be part of the solution in promoting an active lifestyle, the benefits of which are well known.¹¹⁻¹⁵ However, sports injuries are adverse effects of this practice and may hamper participation in physical activities.¹⁶ In addition, there are substantial costs of sports-related injuries, making these injuries also a societal problem.^{17,18} As sports injuries are a barrier to the promotion of physical activity and result in costs for society, efforts should be made to prevent them. It is well recognized that the first step towards sports injuries prevention is the measurement of the health and societal burden of sports injuries.¹⁹ This has been done in research, but it is still a challenge to implement on a broad scale in everyday practice. Continuous monitoring of sports injuries should be implemented in any sporting environment, whether individual or team sports. Early identification of injury and availability of evidence-based interventions are the key factors for sports injuries prevention and treatment, and this is possible only with a reliable and valid injury-monitoring system. The purpose of this paper was, therefore, to review the basic concepts of injury monitoring and to discuss the implementation of these concepts in practice in order to provide a guide for those who want to implement sports injuries monitoring systems.

WHAT IS SPORTS INJURY?

There are many studies addressing the importance of defining 'injury' in research, and this is also an important topic that should be taken into account in practice. In order to truly prevent or manage injuries on the field, firstly it is necessary to define what is considered an injury. Figure 1 exemplifies the course of a musculoskeletal problem (i.e. sports injury) over time. If the definition of injury was based on the symptom 'pain', the injury has lasted 17 weeks (week two to 19). However, if the definition was based on time-loss (i.e. missing training or competition), the injury has lasted three weeks (week eight to 11). In both cases, one is dealing with the same musculoskeletal problem (Figure 1). However, there are two different interpretations. The grey area above the pain or the time-loss threshold represents the severity (discussed later in the paper), or the burden caused by the injury, once the definition is based on these thresholds. It is clear that the grey area above the time-loss threshold is much smaller than the grey area above the pain threshold, meaning that these two definitions lead to two very different conclusions about the injury severity or burden.

Sports injury definition

The term 'sports injury' is used to refer to a variety of musculoskeletal damage caused by sports participation.¹⁹ However, 'damage' may be interpreted and recorded in different ways.¹⁹ Recently, studies have provided some consensus helping to standardise the definition and/or classification of injuries,²¹⁻²⁹ improving the comparability between studies, settings, sports facilities, injury-measurement systems, and also between different time-points. There are general definitions, such as 'injuries are considered disorders of the musculoskeletal system or concussions',³⁰ and specific definitions, such as injuries requiring medical attention (i.e. an injury that leads to health care utilisation) or injuries leading to time-loss (i.e. injuries that hamper the ability to fully participate in sports for at least one training session or competition). Also, there are recommendations on injury for specific sports, such as cricket,²⁴ football (soccer),²⁵ rugby,²⁶ tennis,²⁷ horse racing,²⁸ athletics,²³ and running.²⁹ What is considered an injury will depend on the specific purpose of the surveillance, which

may vary between different sports or settings. However, it is fundamental to appropriately define what is going to be measured.³¹

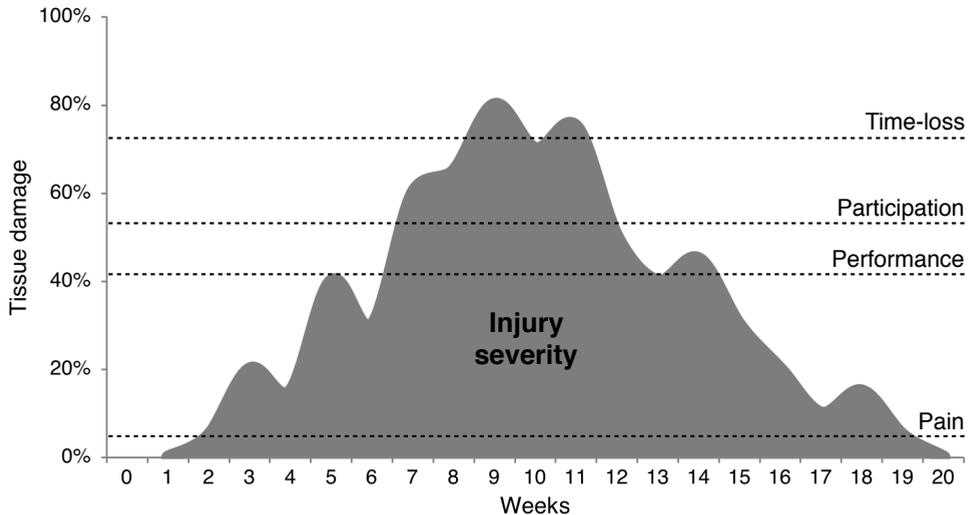


Figure 1. Example of the course of a sports injury over time.²⁰ The thresholds (dashed lines) represent the amount of musculoskeletal tissue damage (in percentage) necessary to result in pain, hamper performance, hamper participation in sports, or result in time-loss (training or competition sessions missed). The grey area represents the severity or burden related to the injury.

Sports injury classification

Mechanism

Different injuries can have different characteristics, causes, and consequences. Therefore, they should be classified in order to elucidate the injury process. The mechanism of the injury drives the initial classification. Acute injuries are those which the onset can be linked to a specific, identifiable and sudden injury event,³⁰ while overuse injuries are those with a gradual onset resulting from repetitive micro-trauma, without a specific and identifiable event causing the problem.²² This classification may guide the health care approaches regarding prevention, treatment or prognosis.

Subsequent injuries

It is not uncommon for an athlete to report more than one injury during a season. Therefore, subsequent injuries should be measured as well. Subsequent injuries can be classified as a new injury (not the same injury as the initial injury; e.g. an injury to another body region) or as a recurrent injury. Recurrent injuries occur in the same body location and usually are of the same nature and/or mechanism. They can be further classified as re-injury (when the injury has fully healed) or as an exacerbation (when the injury has not fully healed).^{21,32}

Classification according to consequences

Medical attention and time-loss classifications are also very common. They are frequently used to define an injury (as discussed previously). For example, a study involving recreational runners was conducted based on a time-loss definition: ‘[...] any pain of musculoskeletal origin attributed to running and severe enough to prevent the runner from performing at least one training session [...]’.³³ It could also be that the same study had a definition based on medical attention, e.g. ‘any pain of musculoskeletal origin attributed to running and resulting in a healthcare professional consultation’.

Although using these classifications (i.e. medical attention and time-loss) is important to provide information on injuries, using these classifications to define an injury raises concern. It is possible that athletes do not consult medical professionals for some minor injuries. Additionally, medical attention is strictly dependent on health staff availability, which may not be a reality in many settings. Using the medical attention definition, therefore, could result in an underestimation of the number and burden of injuries. Similar reasoning can be used for the application of a time-loss definition. Minor injuries are no longer registered or monitored in the injury registration system if they cause no sport time-loss (Figure 1).

Minor injuries are not severe in nature; however, they frequently occur in sports and may pose a large problem. In practice, monitoring 'minor' injuries (or complaints) contributes to an early identification of injuries, enabling earlier interventions to prevent these injuries from becoming more severe, and reducing the burden on the athlete, team, and/or health care system. Therefore, we suggest using the 'medical attention' and 'time-loss' concepts for classification purposes and not as criteria to define a recordable injury.

Formal and non-formal diagnosis

Injuries are also classified according to the body region affected (e.g. ankle) and/or by their type (e.g. sprain). This helps one to understand what are the most common injuries in a given sport and, therefore, guide the prevention and treatment interventions. The best way to do so is to have a formal diagnosis given by a sports health professional or medical staff. However, this is not always possible because of practical/logistic reasons. Therefore, there are other methods to classify such injuries to have sufficient information on them. Two examples on how to do this in practice are the classifications proposed by Timpka et al.²³ and the Orchard Sports Injury Classification System (OSICS).³⁴ In the method of Timpka et al.,²³ an injury can be classified according to body region (e.g. ankle), type of injury (e.g. sprain), and its onset (i.e. sudden or gradual). In the OSICS system, an injury can be coded using four characters: the first relates to the body region, the second relates to the tissue affected or the pathology, and the third and the fourth characters further describe the pathology or broaden the diagnosis.^{34,35} For example, the code KJAP means Knee injury with a Joint sprain involving the Anterior cruciate ligament, although it is a Partial injury. An isolated rupture would be classified as KJAR.

MEASURING SPORTS INJURIES

Once the number of injuries is identified, it is time to put this number into context. The number of injuries by itself does not mean much if the number of individuals at risk and/or the exposure to the sport are not considered. This information will help one to understand the extent of the problem and to make comparisons between different time-point measurements in a single population or team, or between different populations or teams. This is important in order to draw conclusions on whether or not the population or team has been reporting more injuries than expected, as well as to be able to generalise the number of injuries to a certain population. Consequently, specific interventions can be discussed and implemented.

Population at risk and exposure time

Individuals can only be at risk of experiencing sports injuries if they participate in sports. It does not make sense to measure the proportion of football injuries in individuals who do not play football, for example. Therefore, the population at risk in sports is the population exposed to the sport investigated. Suppose 300 football players were injured during a season. Think about the impact of these 300 injured players if the source population consisted of 10,000 or 500 football players (i.e. individuals at risk). The probability of sustaining an injury during one season would be, in the first case 0.03 (300/10,000), or 3%. In the second case, the probability would be 0.6 or 60% (300/500), a much higher figure. Therefore, to measure the burden of injuries, it is necessary to know the total population at risk or the source population who would potentially sustain an injury.

Exposure time is also an important measure and concept. Even if all individuals practice sports in a source population (i.e. the population at risk), differences in exposure may lead to differences in injury risk. Individuals who practice sports once a week for one hour (i.e. sports exposure of one hour per week) are less exposed than individuals who practice five days a week for two hours (i.e. sports exposure of 10 hours per week). The practice of sports is a necessary cause for sports injuries.³⁶ This

means that, theoretically, those who are more exposed to sports are more likely to sustain sports injuries (if all other variables are controlled). For example, if 50 new injuries were registered in a population comprised of 200 athletes, and the total sport exposure time for this population was 5,000 hours, one could say that the injury incidence in this population was 10 injuries per 1,000 hours of practice. However, if the exposure time was 2,000 hours, the injury incidence would be 25 injuries per 1,000 hours of practice, which is 2.5 times higher, while the number of injuries is the same. Calculations using the entire source population (i.e. population at risk) or the sport exposure are discussed later in the chapter.

Prevalence

Prevalence is the number of people with a given health problem (i.e. the number of cases) in a defined population at any given point in time (Equation 1).³⁷ In sports, prevalence is usually reported at a specific time-point (e.g. in the middle of the season) – what is known as ‘point prevalence’. However, in some reports, prevalence is also defined as the period prevalence (e.g. entire season). Prevalence is often used to report the overall extent of the sports injury problem. Suppose a sports manager wants to measure how many football players are injured exactly in the middle of a season. If it is known that in this specific time-point, 50 out of 500 football players are injured. The prevalence (Equation 1) of football injuries in the middle of the football season would be 0.1, or 10% in this example.

$$Prevalence = \frac{\text{cases (injured individuals)}}{\text{entire source population}} \quad (1)$$

Incidence

Incidence is the number of new events that occurred in a given population at risk during a period of time.³⁷ To identify the onset of events (e.g. injuries) and then to be

certain that the events are new, a continuous (i.e. longitudinal) measurement is needed. Incidence can be expressed as a proportion (i.e. incidence proportion or risk) by dividing the number of new injured participants (i.e. the number of cases) by the total number of individuals at risk (i.e. the entire source population) during a period of time (Equation 2).³⁸ As an athlete may have more than one injury over a period of time (e.g. a season), the clinical incidence can also be calculated. Clinical incidence (Equation 3) is the number of events (i.e. the number of new injuries) divided by the total number of individuals at risk (i.e. the entire source population).³⁸

$$\text{Incidence proportion} = \frac{\text{new cases (new injured individuals)}}{\text{entire source population}} \quad (2)$$

$$\text{Clinical incidence} = \frac{\text{number of events (new injuries)}}{\text{entire source population}} \quad (3)$$

Incidence can also be expressed as incidence density (or incidence rate); i.e. the number of injuries (note that participants can have more than one injury over a period of time) by the exposure (i.e. person-time) to the sport investigated (Equation 4).³⁹ Exposure refers to the period from the beginning to the end of the measurement for non-injured individuals. For injured individuals, the exposure is from the beginning of the measurement until the time the injury was identified (i.e. time-to-injury). Person-time is an epidemiological term often used to describe exposure, and it means that the exposure of each individual was calculated and then added (i.e. the sum of person-time exposure) to the incidence density calculation.³⁸

In sports, the exposure can be expressed as hours of participation, days (training or competition), or distance (e.g. kilometres). The incidence density is usually expressed by the number of events per 1,000 or 10,000 person-units of exposure. Even though

different types of exposure units are described, efforts are needed to achieve a common measure. For instance, a study in field hockey reported an incidence density of 7.87 injuries per 1,000 player-games and 3.7 injuries per 1,000 player-training sessions.⁴⁰ Although this information gives the impression that more injuries were identified during games than during training sessions, this conclusion might be misleading because the time of exposure may not be the same. A game could have lasted 1.2 hours and a training session could have lasted five hours, but they will still count as one unit for both game and training sessions, which makes the comparability between the incidence densities problematic. Therefore, we suggest that the exposure to sport should be expressed using units of time, such as hours, in order to facilitate the interpretation and comparison between different sports (e.g. field hockey and football) and types of exposure (e.g. training or competition), unless a relevant reason justifies otherwise.

$$\textit{Incidence density} = \frac{\textit{number of events (new injuries)}}{\textit{total exposure (e.g.hours of sports participation)}} \quad (4)$$

Consider a population of 500 football players. Suppose 70 new injuries were identified in 50 athletes, and the total exposure (i.e. the sum of injured and non-injured player-time of exposure) was 20,000 football hours. The incidence proportion (Equation 2) of this example is 10% (50 new cases divided by 500 individuals at risk) and the incidence density (Equation 4) is 0.0035 (70 new injuries divided by 20,000 hours), or 3.5 injuries per 1,000 hours of sport exposure (0.0035 multiplied by 1,000). Note that the incidence density takes into account the number of injuries, which is suitable since an athlete may sustain more than one injury during a certain period of time (e.g. a season).

Prevalence and incidence applications

Prevalence rather than incidence is usually used to describe the overall burden or extent of the sports injury problem. If the question is 'how many athletes are expected to have sports injuries?', the recommended measure would be prevalence. However, most sports managers are more interested in the risk of injury. In this case, incidence proportion is the best option to answer the following question: 'what is the risk of sustaining an injury?'. If athletes can have more than one injury during a period of time, and one wants to know what the frequency of injuries is in a certain population, then the clinical incidence is a good measure. Incidence density is widely used to answer the following question: 'how many injuries would be expected for a certain amount of exposure?'.³⁸ This is an interesting question because an individual cannot have an injury if he or she is not exposed to the sport being investigated.

The issue of measuring overuse injuries in sports should also be considered. By definition, overuse injuries are those with a gradual onset. It is difficult to identify precisely the real onset of these injuries. In addition, the symptoms of an overuse injury could present as a sudden onset, whilst the course of the injury is actually a long-term process. This phenomenon makes things even more difficult.²⁰ Therefore, it has been suggested that the mean prevalence, calculated based on the prevalence repeatedly measured over different time-points, is a better measure of the sports injury magnitude than incidence for overuse injuries.^{20,41}

Injury severity

Measuring the severity of injuries is essential to understand the extent to which sports injuries impact athletes' health.¹⁹ Different aspects are used to determine the severity of sports injuries such as nature of the injury, duration, medical attention, sports time-loss, working time-loss, permanent damage, and costs of sports injuries.⁴² This emphasizes the importance of appropriate injury monitoring and classification.

The nature of a sports injury is one indication of its severity. A concussion is more likely to be more severe than a blister. A similar reasoning occurs with the anatomical location of injuries. A blister on the foot or toe in a runner may have different consequences than the same injury in a rower. Despite nature and anatomical location, the extent of symptoms and other consequences of injuries are also important measures. Individual characteristics, the energy involved at the moment of injury occurrence, and the injury mechanism are examples of how the same injury in different individuals from the same source population may lead to a different classification of severity.

Mapping the duration of injury also contributes to its severity measure. For this and other reasons, continuous monitoring (i.e. longitudinal data) is essential. An ankle sprain might be considered more severe than an Achilles tendinopathy in the short-term. However, the overuse mechanism of the Achilles tendinopathy might lead to a longer recovery period than an ankle sprain with an acute onset. Therefore, in the long-term, the Achilles tendinopathy may result in greater consequences to the athlete, leading to a higher severity classification than an ankle sprain.

Medical attention and time-loss are also examples of severity. An injury that requires medical attention is likely more severe than an injury that does not. Similarly, if an athlete is not able to participate fully in his/her usual sporting activities due to an injury, the time-loss indicates the severity of this injury. From a societal perspective, injuries sustained during sports participation may have consequences for other activities. Working time-loss, for example, can also be used as a measure of severity, since it is not unusual that people are not able to work because of sports injuries.

Most athletes recover from sports injuries without a permanent disability (residual symptoms).⁴² However, injuries such as concussions with brain damage, spinal injuries, or eye injuries may lead to permanent damage. Injuries that lead to permanent damage are clearly more severe than injuries that do not. The costs of sports injuries are also important to determine their severity.

Economic costs

The monetary cost related to sports injuries are usually described as a measure of their severity.⁴² In general, severe injuries lead to higher monetary costs due to medical consultations, medications, medical devices for treatment, and productivity loss.⁴² All costs related to sports injuries are usually taken into consideration in an economic evaluation, no matter who pays or receives the payment.⁴³ This is an approach from the societal perspective. There are four typical classifications of economic costs from this perspective:^{42–45}

- Direct costs or healthcare costs: costs related to healthcare utilization, such as consultations with a general medical practitioner, sports physician, medical specialist (e.g. orthopaedic surgeon), physical therapist, massage therapist, alternative therapist, the use of hospital care, medications, and medical devices (e.g. crutches, tape, braces).
- Indirect costs or loss of productivity costs: costs related to loss of productivity due to absenteeism from paid or unpaid work (e.g. household work, loss of study time, loss of leisure time) or due to presenteeism (i.e. not being able to perform fully at work as a result of the injury).
- Societal costs: includes insurance administration costs, costs related to insurance programs, workers' compensation costs (i.e. workers may receive wage replacement and/or medical benefits due to sick leave,⁴⁴ and litigation costs (i.e. legal and court costs related to time spent by lawyers and judges, contribution made by legal support services, and overhead expenses).
- Social costs: costs related to the psychological burden of the injury (e.g. depression, social isolation, and economic dependence).

Costs data should be collected and monitored by a reliable and continuous injury registration system.⁴² Besides the challenge of continuously monitoring such costs, the evidence on economic costs of sports injuries has been growing, especially for direct and indirect costs.^{17,18,46,47} Data on societal and social costs is less common because

they are more difficult to measure and estimate. Moreover, social costs are considered 'unquantifiable' because of the difficulty in measuring them.⁴²

Challenges in economic data analysis

An economic evaluation requires the collection of data on such things as the number of (para)medical consultations, medications uptake, the number of medical devices used, loss of paid working productivity hours/days, loss of studying hours/days, and loss of leisure time hours/days. However, this is not enough. After data collection, it is necessary to transform the number of consultations, loss of productivity, and societal and social consequences into a monetary value.

The Dutch health care system maintains a continuous registration of economic costs-related data. From a central website,⁴⁸ it is possible to download a full report of all the relevant information on the costs related to healthcare. If additional information is necessary, the Dutch Central Bureau of Statistics website⁴⁹ provides a variety of additional information (e.g. average hours spent during paid work by age and gender). Therefore, the Dutch system allows a very reliable economic evaluation for those interested in conducting such analyses in the Netherlands.

In Brazil, the differences in socioeconomic groups and availability of medical care and costs (e.g. public and private systems) make the economic evaluation even more challenging. However, the Brazilian public healthcare system (SUS) also keeps continuous records of health-related data through the SUS database (DATASUS).⁵⁰ Within this database, it is possible to find a plethora of information such as the number of healthcare consultations and hospitalizations, costs, and income per capita. DATASUS may be an important tool to perform economic evaluations on sports injuries in Brazil and should be used for this purpose.

SPORTS INJURIES MONITORING SYSTEMS

Injury monitoring has been performed in a variety of ways in research and practice. It can vary from very simple and non-validated surveys³³ to more sophisticated and validated injury-management systems.^{30,51} Regardless of the vehicle used to collect injury data, the aspects discussed previously should be addressed in all of them.

There are several injury-monitoring systems that record sports injuries over time in a continuous (i.e. longitudinal) manner, and also measure sports exposure.⁵¹⁻⁵⁴ Some of these systems measure exposure indirectly and provide estimations. For example, a team of 50 players with 20 training sessions and 5 competitions may have 1,250 athlete-exposures (50 multiplied by 25). Examples of this approach are the National Athletic Injury Reporting System (NAIRS), Canadian Athletic Injury/Illness Reporting System (CAIRS), NCAA Injury Surveillance System, Sports Injury Monitoring System (SIMS), National High School Athletic Injury Registry, and Athletic Injury Monitoring System (AIMS).⁵⁴ However, systems can measure individual's sports exposure directly and, therefore, may be able to provide more accurate measures that are dependent on sports exposure (e.g. incidence density). Examples of this approach are the Athletic Health Care System (AHCS), Sport Injury/Illness Reporting System (SIIRS), Canadian Intercollegiate Sport Injury Registry, the IOC Injury Surveillance System for Multi-Sports Events, Training and Injury Prevention Platform for Sports (TIPPS), and the Sports Injury Tracker.⁵¹⁻⁵⁴

There is a debate over the differences between systems regarding to appropriate measures for acute and overuse injuries.^{20,30} Many injuries that occur during tournaments and/or participation in contact sports have an identifiable acute onset, and most of the monitoring systems are effective in identifying these injuries. Therefore, these systems provide reliable information for incidence calculations. However, in many endurance sports, most injuries occur by repetitive movements, with a gradual onset (i.e. overuse injuries). The onset and symptoms of overuse injuries are very difficult to record in these systems because of the gradual onset and transient mechanism of such injuries.²⁰ In this case, the incidence is almost impossible to be measured accurately. Therefore, a monitoring system was developed in order to deal

properly with overuse injuries⁴¹ and was further broadened to monitor any sort of health problems in sports: the Oslo Sports Trauma Research Center (OSTRC) Questionnaire on Health Problems.³⁰

The OSTRC questionnaire prospectively registers health problems asking four key questions: (1) the extent in which a health complaint has affected sports participation; (2) training volume; (3) performance; and (4) the extent in which the individual has experienced health symptoms. Based on the response to these four questions, a severity score ranging from zero to 100 is generated. The registered health complaint is then further categorised as an injury or illness. For the purposes of this paper, only the injuries will be discussed.

The OSTRC questionnaire is based on weekly measures of injury prevalence, and the mean of the weekly prevalence within a period of time (e.g. a sporting season), together with its 95% confidence interval, is used to summarise the prevalence measured repeatedly over time. Moreover, it is possible to identify the first report of an injury, which enables the calculation of the incidence of acute injuries. The developers of this questionnaire recommend that a medical staff should diagnose the injuries captured through this system.³⁰ However, if this is not possible, the tools previously discussed could be used for this purpose. The severity score of the OSTRC questionnaire can provide an overview of the injury course over time and differentiate periods of lower and higher severity (Figure 1).

Due to the ability of the OSTRC questionnaire to deal with both acute and overuse injuries, our research group has been using this questionnaire to collect injury data on a variety of sports. The English version of the OSTRC questionnaire can be found elsewhere.³⁰ In addition to the OSTRC questionnaire, sport-specific questions on exposure (usually in hours of training and competition) and costs related to injury are also included. Costs data are usually neglected in injury monitoring systems in spite of their well-recognised importance, which may lead to an underestimation of the overall burden of sports injuries.

Applied example and implications for practice

An example of how injury data collected by these monitoring systems may be displayed for analysis and interpretation is presented in Figure 2. The black lines represent the duration of injuries from onset or from the time they are first reported (black circles). The grey area represents the variation in severity over time for each injured athlete. With this monitoring chart, one can identify periods when athletes reported more injuries and/or periods when the severity of injuries was higher, such as weeks two, six, and seven in Figure 2. The implication is that the trainer or the medical staff can verify what happened during this period (e.g. a specific competition or a period in which a specific training program was implemented) and develop strategies to prevent this from happening again. Moreover, after the introducing a preventative strategy, they can see if it was effective in decreasing the prevalence, incidence, and/or severity of all or specific injuries while the surveillance is maintained.

A more tailored approach could be the early identification of injuries for the implementation of early interventions. The early identification and early intervention could prevent minor injuries from becoming more severe, and minimise consequences for athletes' sports participation, health, and societal consequences. This could be done with the individuals 10 and 16 in Figure 2 since it is clear that in early stages the injury severity was not high, but it got worse over time. Maybe this progression could have been prevented. Secondly, the early identification and intervention can prevent the injury from getting worse and lead to permanent damage. Individuals eight and 20 in Figure 2 are examples of an early identification and intervention leading to a faster recovery.

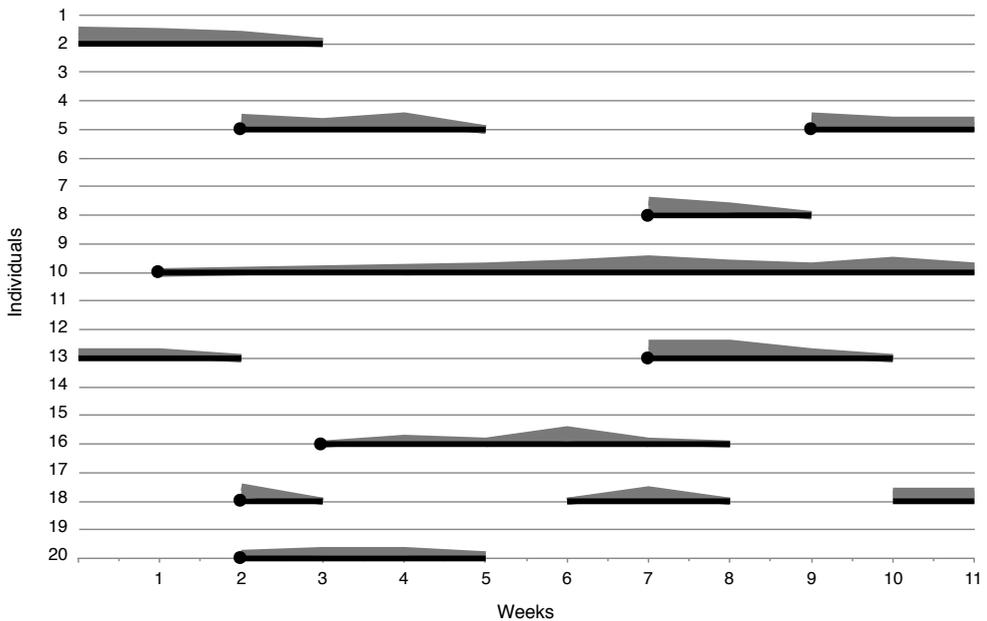


Figure 2. Example of how sports injury monitoring data may be presented in a population level.²⁰ The black lines represent the duration of the injuries since their onset or first report (black circles). The grey area represents the variation of severity over time.

ONLINE TECHNOLOGY

The usage of online technology is becoming a reality worldwide. It is estimated that more than 40% of the world population used the internet in 2014.⁵⁵ In Brazil, more than 50% of the population used the internet in the same year, and this number is growing.⁵⁶ Therefore, there is a lot of opportunity for e-Health solutions, which means ‘the use of information and communication technologies (ICT) for health’.⁵⁷ In sports, e-Health can be used to monitor injuries in a variety of ways. Online platforms have been used widely in sports injury research since it is possible to create questionnaires and send a link to these questionnaires (usually by email) and the answers can be downloaded afterwards.

Sometimes this requires cooperation between sports, medical, and ICT personnel to create an online platform. However, now there are several open-source and

commercial online platforms in which one can simply embed a questionnaire and start sharing it. Another way to collect data in order to monitor injuries is by text messaging (e.g. short message service – SMS). This method has been increasingly and successfully implemented⁵⁸⁻⁶¹ since more and more people are using mobile phones or other portable devices (m-Health).⁶²

Advantages of using online platforms include:^{63,64} (1) self-entering data by the participant or athlete, which eliminates the manual entry by the sports manager, increases the fidelity of the data, and minimises the chance of reporting bias; (2) response fields can be predefined with a reasonable range of possibilities, eliminating errors and out-of-range data; (3) reminders may appear if the individual skips some mandatory questions, eliminating missing data and increasing the accuracy of information; and (4) the possibility of branching questions based on the previous responses, saving time, minimizing the burden of answering the questionnaire, and still maintaining the individuals' motivation to continue answering the questionnaire over time.

Privacy and confidentiality issues are the major concerns about the usage of online technology.⁶² Privacy is the right of an individual not to have his/her private information exposed, and confidentiality is the permission to access information by authorized individuals only.⁶⁵ An unprecedented amount of an individual's information can be collected and stored in online platforms, and the terms and conditions of use of these platforms cannot violate the privacy and confidentiality rights of the individual. For example, one may have consented to provide information to be used by the team staff but has not consented for commercial use of the information by third parties.⁶² These issues must be considered beforehand to avoid misuse of information.

The use of online technology in sports practice is still challenging. Even with the increasing number of internet and portable device users, not all individuals can be reached by such technology. In addition, different populations may use online resources differently, meaning that the questionnaire should target the population of

interest (e.g. adolescents or elderly). Another important aspect is the validity of using existing questionnaires on an online platform. Questionnaires created and tested in a paper version may not have the same clinimetric properties of the online version. Such tools should then be also tested in the online environment. Finally, the online technology does not substitute the personal contact between the athlete and the trainer, medical staff, or sports managers, which is invaluable.⁶² It is recommended that both approaches should be used in order to optimise and improve the monitoring of sports injuries.^{30,62}

CONCLUSIONS

Today, the development of a system to monitor injuries in individual or team sports is not only feasible but also strongly recommended. Many tools have been developed and proven to be implementable and manageable, and they are waiting to be used. This paper reviewed the most important aspects of injury-monitoring systems for sporting populations and/or facilities, and we recommend their immediate use. Only with this information collected on the long-term will it be possible to truly identify the burden of sports injuries; enable early identification of possible cases and prevent them from becoming injuries with greater consequences for athletes' sport participation, health and social activities (including work); enable comparisons within or between sports modalities; and have sufficient data for sports injury prevention and treatment. Although plausible considerations may differ between different settings, the information acquired by continuous injury surveillance in sports is the key for the management of sports injuries.

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