*Theisen D[1], Malisoux L[1], Seil R[1,2], Urhausen A[1,2]*

# Injuries in Youth Sports: Epidemiology, Risk Factors and Prevention

## *Verletzungen im Jugendsport: Epidemiologie, Risikofaktoren und Prävention*

[1] Sports Medicine Research Laboratory, Public Research Centre for Health, Luxembourg, Großherzogtum Luxemburg
[2] Sports Clinic, Centre Hospitalier de Luxembourg, Luxembourg, Großherzogtum Luxemburg

## SUMMARY

Organised youth sport has become increasingly professionalised, and the associated sports injury problem has received much attention lately. Sports injury prevention should rely on permanent surveillance and encompass the collection of epidemiological data, the establishment of risk factors, the implementation of prevention initiatives and the analysis of their effectiveness. Overall, injury incidence in youth sport is usually within a range of 1-10 injuries/1000 hours. About one fifth of all injuries are severe, implying a withdrawal from normal sport activity for at least 4 weeks, while up to 20 % of all injuries are recurrences. Chronic overuse injuries amount to up to 40 %, many of which concern episodes of traction apophysites, typical in youth sports. Risk factors can be extrinsic (e.g. sport context) or intrinsic (e.g. gender), modifiable (e.g. neuro-muscular control) or non-modifiable (e.g. previous injury). Injury risk is higher in team compared to individual sports and in competition compared to training. Active sports injury prevention initiatives have been introduced and tested in a number of controlled studies. Putting aside a possible publication bias, most results are encouraging, showing a possible reduction of injuries by 50 % on average. Modern information technology can provide excellent solutions to assist in sports injury surveillance and prevention. One example of such an infrastructure is the Training and Injury Prevention Platform for Sports (www.tipps.lu) developed by the Sports Medicine Research Laboratory (CRP-Santé, Luxembourg).

**Key Words:** sports injuries, injury incidence, injury mechanism, injury surveillance

## ZUSAMMENFASSUNG

Der organisierte Jugendsport hat sich in den vergangenen Jahren zunehmend professionalisiert. Dem damit verbundenen Problem der Sporverletzungen wurde hierdurch zunehmend Aufmerksamkeit verliehen. Die Prävention von Sportverletzungen sollte auf einer permanenten Überwachung basieren, welche die Sammlung von epidemiologischen Daten, das Bestimmen von Risikofaktoren, die Umsetzung von Präventionsinitiativen und die Analyse ihrer Wirksamkeit beinhaltet. Insgesamt liegt die Verletzungsinzidenz im Jugendsport im Bereich von 1-10 Verletzungen/1000 Stunden. Ein Fünftel davon ist gravierend und zwingt zur Aufgabe der gewohnten sportlichen Aktivität für eine Dauer von mindestens 4 Wochen, bis zu 20 % davon sind Rezidivverletzungen. Chronische Überlastungsschäden belaufen sich auf bis zu 40 % aller Verletzungen, wovon viele die häufig im Jugendsport auftretenden Traktionsapophysitiden betreffen. Risikofaktoren können extrinsisch (z.B. Sport-Kontext) oder intrinsisch (z.B. Geschlecht), modifizierbar (z.B. neuromuskuläre Kontrolle) oder nicht-modifizierbar (z.B. Z.n. früheren Verletzungen) sein. Das Verletzungsrisiko liegt in Mannschaftssportarten und unter Wettbewerbsbedingungen höher als im Einzelsport und im Training. Verschiedene Initiativen zur Prävention von Sportverletzungen sind bisher eingeführt und in einer Reihe von kontrollierten Studien wissenschaftlich untersucht worden. Eine Mehrzahl hiervon zeigte ermutigende Ergebnisse mit einer Reduzierung der Verletzungszahlen von durchschnittlich 50 %. Moderne Informationstechnologien, wie z.B. die vom sportmedizinischen Forschungslabor am CRP-Santé, Luxembourg entwickelte Trainings- und Präventionsplattform für Sport (www.tipps.lu), können bei der Überwachung und Prävention von Sportverletzungen eine ausgezeichnete Hilfestellung leisten.

**Schlüsselwörter:** Sportverletzungen, Verletzungsinzidenz, Verletzungsmechanismus, Verletzungsüberwachung

## INTRODUCTION

Over the past decades, organised youth sports has become more and more professionalised, as reflected by an ever increasing training volume and early specialisation. As a consequence, associated sports injuries have received much attention lately, not only because of the possible short- and long-term consequences for the young athlete, but also because of the economic burden these injuries represent. Therefore, research into sports injury prevention has been strongly promoted lately (7). Leading scientific experts have proposed a very simple and efficient model to organise sports injury prevention initiatives, based on a 4-step approach (31) which includes 1. the collection of epidemiological data to establish the extent of the sport injury problem, 2. the identification of the underlying mechanisms and risk factors, 3. the introduction of prevention initiatives to reduce these risk factors and 4. the assessment of these initiatives regarding their effectiveness, which actually comes down to repeating step 1. Ideally, in a given sport context, effective sports injury prevention should be envisioned by cycling repetitively through this model. In practice, however, many challenges are associated with such an undertaking, including the availability

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of manpower with the necessary expert knowledge, a strong methodology and infrastructure for data collection and, most of all, a durable collaboration with the concerned stakeholders, that is the coaches, the parents and, of course, the athletes.

Given the considerable amount of recent literature on the topic of injury surveillance and prevention in youth sports, it is beyond the scope of this paper to provide a complete state-of-the-art picture. Rather, the aim of this contribution is to offer a brief introduction to readers less familiar with the different aspects related to this area, using the above described 4-step model as a reference frame. A second aim is to present one particular example of an internet-based sports injury surveillance system to illustrate how modern information technology can help overcome some of the many challenges associated with such an endeavour. Since this is a brief, narrative review covering different topical aspects, the readers should be cautioned that the literature referred to be not selected based on a systematic search strategy and may present some degree of bias.

## EXTENT OF THE SPORTS INJURY PROBLEM

As already highlighted above, the first phase in sports injury prevention concerns the description of the problem in terms of injury incidence, severity and type. Injury incidence in youth sports has been reported to be in the range of 0.5 to 34 injuries/1000 hours (2). However, it should be highlighted that depending on the study objectives, the sport context analysed or the methodology used, the results can vary considerably. For example, the injury definition can have a pivotal impact on the outcome and thus influence the study conclusions (1). One definition that has been recently used in youth sport is the time-loss definition, according to which the event of interest is any physical complaint caused by sports participation and that forces the athlete to interrupt or modify his/her usual training plan for at least one sport session (10,17). This definition has the advantage of being easily understood both by athletes and trainers. According to this classification, Malisoux and coworkers (18) prospectively followed 372 athletes (12–19 years) from 16 different disciplines and reported incidences of 1.3-3.0 injuries/1000 hours for racket sports, 2.0-3.8 injuries/1000 hours for individual sports and 4.6-6.5 injuries/1000 hours for team sports. Recurrences (11) (same type of injury in the same anatomical location during the preceding 12 months) varied between 11 and 26% in that same study (18). The analysis of injury severity across several popular sport disciplines revealed that 15-21% of all injuries lead to less than 7 days of absence from normal sporting activity, while those interrupting sport practice for more than 4 weeks amount to 15-22% (18,23,28). Overuse injuries, caused by microtrauma following chronic overload, tend to be frequent in young athletes during their growth spurt, totalising 30-40% of all injuries recorded (18,24,28). Typical chronic lesions of this population are traction apophysites such as the Osgood-Schlatter (23), Sever (23) or Sinding-Larsen-Johansson disease (14).

## RISK FACTORS

Much effort has been undertaken to understand what the underlying causes of sports injuries are. The injury mechanisms and involved risk factors are in the majority of cases sport-specific. It must also be remembered that, except for accidents, a sport injury can rarely be ascribed to a single factor, but rather to an association of causes or circumstances. Finally, it has been proposed that the injury risk of an individual athlete may not be constant, but is likely to change over time. Of relevance here is, on the one hand, the presence of intrinsic and contextual factors, and, on the other hand, the repetitive exposure to training and "inciting events" that do not cause injuries, but may induce some kind of adaptation of the athlete's risk profile. For an extensive discussion on these aspects, the reader is kindly referred to the publication of Meeuwisse and coworkers (21).

**Table 1:** Potential risk factors involved in sports injury causation.

| | Modifiable | Non-modifiable |
|---|---|---|
| Intrinsic | Fitness level | Age |
| | Sport-specific training/warm-up | Gender |
| | Muscle strength | Maturity level |
| | Flexibility | Previous injury |
| | Joint stability | |
| | Biomechanical factors | |
| | Balance/proprioception | |
| | Psychological factors | |
| Extrinsic | Rules and regulations | Type of sport |
| | Coaching education/training | Sport context |
| | Playing time | Weather conditions |
| | Playing surface | Level of play |
| | Equipment | Time of season |
| | | Playing position |

Table 1 displays the most commonly cited factors in relation to sports injuries (7). A first distinction is made between those that are modifiable and those that are not. In addition, risk factors have been classified as extrinsic or intrinsic, depending on whether they are related to external circumstances/sport context or athlete characteristics. Not all have been systematically studied in youth sports, and some results in the literature regarding their role are inconsistent. Therefore, the following discussion will touch upon only some of the most relevant factors (Table 1).

The type of sport is a first determinant to take into consideration, since different sport disciplines will most likely entail specific injury risks. Direct comparisons of prior investigations are, however, difficult, due to the differences in the study objectives and methodologies used. Team sports have been found to have a higher (up to 2-fold greater) injury risk compared to individual sports (8,28). Sport context is another interesting variable regarding injury risk. While in absolute terms more injuries are generally associated with training, compared to competition, it must be noted that athletes also spend much more time in that context. As a consequence, as shown in youth football (9,16), the number of injuries per 1000 hours of exposure is much higher in the context of competition (11-24 injuries/1000 hrs) than in training (4-7 injuries/1000 hrs), giving rise to a relative risk of 2.9 (5). This greater injury risk associated with competition has been confirmed in a multisport setting (18).

One intrinsic, non-modifiable risk factor that has been identified rather consistently across a series of studies is previous injury (7). A study on youth football showed that injury risk was 3

times greater in players with two or more previous injuries (15). The contrast with previously uninjured athletes can even be greater when considering recurrences of a specific injury, such as non-contact ankle sprains (30). Age is another often identified risk factor, with adolescents over 13 years being at greater risk of injury than younger children (3).

Personal characteristics related to physical performance are of particular interest, not only for success in sports, but also regarding injury prevention. Indeed, if their role in injury occurrence can be demonstrated, then they can be specifically targeted by active intervention programmes, an aspect that will be addressed later on in the next section. Poor cardio-respiratory endurance (amongst other factors) has been associated with a higher risk for inversion ankle sprain in university students (32), but a relationship with injuries in general could not be found in young football players (9). Some findings indicate that the strength of particular muscle groups could be related to specific injuries, such as ruptures of anterior cruciate ligaments (ACL) (13) or ankle sprains (32), although a coupling a coupling of muscle strength and sports injuries overall could not be established (9). Neuro-muscular control has been suggested to be implicated in non-contact ACL injuries. The results from a prospective observational study on 205 female athletes suggest that increased knee abduction angles, higher knee abduction moments and greater impact forces during standardised landing tasks are related to ACL injuries (13). These findings highlight the potential for interventions focused on neuro-muscular control to reduce these severe and debilitating traumas. Psychosocial factors have been studied to some extent. For example, in youth football, high levels of life stress were associated with injury occurrence in female players (27), while physical fatigue caused by sports practice was found to be predictive in male players (9).

## ACTIVE PREVENTION INITIATIVES

Prevention initiatives undertaken to reduce sports injuries can be of different types. Some strategies involve modifying the rules of the sport discipline, such as imposing the use of protective equipment, e.g. a helmet in cycling. This approach provides some degree of protection without specific cooperation from the athlete other than complying with the regulations. On the other hand, active prevention strategies aim intrinsic, modifiable risk factors and imply a change of attitude or physical characteristics to decrease injury risk. An example of such a prevention program applied to football is the "11+" developed by F-MARC (FIFA Medical Assessment and Research Centre).

A series of high-quality studies using a cluster-randomized controlled design (level of evidence 1) have investigated the potential of active prevention initiatives to reduce sports injury incidence. Some (4,20,22,25) consistently reported significant decreases of injury incidence, but others (6,26) did not demonstrate positive effects. Although a publication bias cannot be excluded here, the literature data show that active prevention initiatives have the potential to reduce sports injuries by some 30-80% (4,20,22, 25). The results are largely variable and depend on the study objectives and intervention used. For these programs to work, some key aspects must be met, as analysed in a recent literature review (7). The first critical point is the content of the prevention program. Much focus has been put on neuro-muscular control, plyometrics, muscle strength, trunk stability, sport-specific agility, flexibility, balance and physical fitness. Most studies have tested interventions comprising several of these aspects simultaneously. A second major point concerns the quality of the execution of the proposed exercises. Proper technique is critical (e.g. lower limb alignment, trunk stabilisation, pelvic control, "knee over toe" position, bilateral landing, reduced impact forces, etc.) and requires close supervision by qualified personnel. Exercises should be graded and sport-specific, which will help maintain motivation and may even be performance enhancing. Finally, the session frequency and the duration of the prevention program need to be taken into account. Possible solutions are either an intense and systematic pre-season program over several weeks, or a continuous program administered throughout the sport season, e.g. under the form of a standard warm-up.

## SPORTS INJURY SURVEILLANCE

As already presented in the introduction, the last step of the sports injury prevention process is to evaluate the effectiveness of the intervention initiatives employed, which means, in fact, to re-assess the scope of the problem (step 1). In other words, effective sports injury prevention implies a continuous process of injury surveillance, which presupposes that the necessary resources and know-how are available to all involved stakeholders.

Platforms relying modern information technology, such as the internet, can help facilitate the constant gathering of data relevant to sports injury surveillance. At the same time, they offer excellent possibilities to enhance the communication amongst involved actors to provide feedback to athletes, coaches and clinicians. One example of such a system is the "Training and Injury Prevention Platform for Sports" (TIPPS), an IT infrastructure that has been developed in the framework of several research projects run at the Sports Medicine Research Laboratory of the Public Research Centre for Health (CRP-Santé), Luxembourg. TIPPS is an electronic database available via the internet that can be used both as a research methodology to gather data about training load and sports injuries (18,17,19,29), as well as a monitoring tool for athletes, trainers and medical staff (cf. www.tipps.lu). To guarantee data confidentiality, each actor has personal access codes and receives a predefined user profile that provides selective and secure data access according to his/her function and prerogatives. Athletes can upload information pertaining to their practice characteristics, such as training hours, context, subjective training intensity and competitions. This information can be reviewed and analysed by the athlete and his/her trainer/coach under numerical or graphical form, thus allowing monitoring of training periodization and total practice load over time, relative quantification of the training contexts/types, comparison and benchmarking with respect to other athletes and appreciation of perceived practice intensity. The athlete also has the possibility to declare episodes of pain or injury for each practice session, providing information based on state-of-the-art literature recommendations (11,10,12). Typical injury characteristics include start and end date of the injury, injury category, affected body parts, injury type and whether the injury is recurrent or not. Declared pains and injuries can be analysed by the medical staff involved in a sports team or federation to ensure optimal follow-up of the athletes and a safe return to full sports practice. Specific injury risk indicators have been implemented into the system to generate lists

of athletes suspected to be at an increased injury risk, based on the recorded information. Other indicators will highlight those athletes showing critical injury characteristics, based on their current injury profile and history. These athletes can be followed-up more closely by the medical team and the trainer/coach before taking the return-to-play decision. TIPPS has many internal cross-check procedures and reminder functions that limit encoding errors and ensure a certain level of data quality. Extensive search features/filters that have been implemented to provide "real-time" feedback to the different stakeholders. In addition, regular post-hoc summary reports can be established, providing a global picture of the sports injury problem in a given sport context (steps 1 and 4 of the 4-step injury prevention model) and, potentially, helping identify injury risk factors (step 3). The TIPPS is currently being used by several Luxembourgish sports federations and individual athletes and serves as a data gathering tool for ongoing research at the Sports Medicine Research Laboratory.

## CONCLUSION

Injuries in youth sports represent a serious public health problem that deserves more attention. Both severe and recurrent injuries can amount up to 20% of all injuries and may have serious short- and long-term consequences for the young athlete. There is sufficient evidence in the scientific literature that it is possible to lower injury incidence through active prevention initiatives, provided certain key aspects are guaranteed. Modern IT infrastructures can provide excellent solutions to assist in sports injury surveillance and, potentially, injury prevention.

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**Corresponding Author**
**Daniel Theisen**
**76 rue d'Eich**
**1460 Luxembourg**
**Großherzogtum Luxemburg**
**E-Mail: daniel.theisen@crp-sante.lu**