Injury Prevention in Athletics: The Race Has Started and We Are on Track!

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ABSTRACT

The practice of athletics involves the risk of injury. Injury prevention and athlete health represent important issues for the athletes themselves plus all the stakeholders in the sport, including national athletics federations and international sports organisations. In this report, an international team of sport medicine experts describes the state of the art in this area and the efforts of the IAAF, European Athletics, the French athletics federation and the Swedish athletics federation to expand the knowledge. They find that the vast majority of studies to date are related to injury rates while necessary understanding of the mechanisms and risk factors of athletic injuries is still limited. Various prevention measures and/or strategies specific to certain injuries have been devised and proposed, however, unlike in football and some other sports, none of these have been scientifically validated for effectiveness. These clearly represent a second relevant direction to follow and develop. The authors conclude by recognising international and national athletics federations for their positive contributions in this area and calling on them to continue their support.

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Introduction

The practise of athletics involves the risk of injury[1,2]. Athletics injuries can affect all tissues constituting the musculoskeletal structure (bone, cartilage, ligament, tendon, muscle, soft tissue…), can be sudden or gradual in onset, and can be caused by acute trauma or repeated microtrauma ("overuse"). They can force the athlete to drop out of a single competition, miss a season or finish his/her career prematurely. Not only do they impact the athlete's sporting activities, with all the challenges this can involve, they can also affect everyday life (school, work, daily activities...)[1].

Injury prevention and athlete health thus represent important issues for athletes as well as for all the stakeholders around them (coaches, managers, family, sponsors…), especially health professionals (physicians, physiotherapists…)[1-6]. It also represents a major issue for national athletics federations[1,20-26] and international sport organisations such as the International Olympic Committee (IOC)[6-11], the International Association of Athletics Federations (IAAF)[12-15] and European Athletics[16-19]. These organisations have committed to work in this area and important progress has been made. It is fair to say that the race to better injury prevention in athletics has started.

VAN MECHELEN et al.[27] described a scientific and clinical research methodology in the field of prevention of sports injuries with a four-step "sequence of prevention": 1) determine the extent of the problem in terms of the incidence, severity and characteristics of the injury; 2) determine the risk factors (intrinsic and extrinsic) and injury mechanisms that play a role in the occurrence of sport injuries[28]; 3) develop preventive measures that are likely to reduce the future risk and/or severity of injuries, based in particular on the knowledge acquired during the second step; 4) evaluate the effectiveness of prevention measures developed in the third step.

In this report, we use this four-step framework to describe the state of the art in injury prevention in athletics, based on our experience as practitioners, researchers and advisors to various sports organisations.

Step 1: Injury Rates

The first step in the process is to determine the extent of the problem through epidemiological studies. The aims of these have been to define / identify the main injuries and most at-risk populations.

Methodology of epidemiological data collection

The data collection method is fundamental to the value of an epidemiological study. Indeed, the quality of the data depends on the quality of the method used[29-32]. Moreover, a method that is reproducible and valid allows comparisons between studies and long-term monitoring.

From a functional point of view, a useful study method must approach the following parameters in a way that is similar to other studies while determining clearly and precisely: 1) the definition of an "injury" (all injuries requiring medical attention or not, causing time-loss or not, etc.) and its characteristics (mode of onset, location, type, cause, severity, etc.); 2) how the exposure is calculated (number of athletes, number of starts, sport practice exposure: hours of training, hours of competition, etc.), which allows the incidence of injuries to be calculated; 3) the study design (retrospective or prospective); 4) the data collection procedures (the tools: paper, computers, Internet, SMS, etc.; who reports the data: doctors, medical, sports teams, coaches, athletes, etc.); and 5) data analysis (prevalence, incidence, subgroups, statistical analyses, etc.).

To date, there is a consensual method for injury data collection during championships that has been developed by the IOC[7] and used in athletics at the IAAF World Championships in Athletics[12-15], the European Athletics Cham-

pionships[16-19], and the French national championships[20]. This method has provided reliable and comparable data for particular events.

If we broaden the focus to the whole athletics season, we find that only a few studies exist and that they use different methods[23,25,33-38], which does not allow a true comparison of the data[3]. A method was recently developed at a consensus meeting of international and national athletics federations that are expected to implement long-term cohort follow-ups over one or more seasons with a comparison between studies[39]. Therefore, injury rates have been presented separately between the data during championships and during the whole season.

Injury rates during the international athletics championships

Injury data has been collected at a number of major championships following the consensus method mentioned above. At each event, physicians and/or physiotherapists from the national medical teams and the local organising committee have been provided with injury definitions and classifications and then asked to report prospectively, using a paper-based report form, on the newly occurring injuries among athletes registered in the championships. The participation and response rate of medical teams, the incidence of injuries and the injury characteristics have then been calculated for each championship. This work has allowed the collection of a large amount of data resulting in a clear vision of injuries that athletes can suffer during international championships[12-19,40,41].

From 14 international championships from 2007 to 2014, a total of 1,510 injuries were reported, corresponding to an incidence of 100 injuries for 1000 participating athletes[41]. Injury risk was significantly higher for male than female athletes (110.3 ± 6.8 *vs.* 88.5 ± 6.7 injuries per 1000 registered athletes, respectively; Relative Risk = 1.25 (confidence interval 95%: 1.13 to 1.32))[41]. The main locations of injuries were the thigh, leg, knee and foot, with a higher incidence of thigh and leg injuries in male athletes. The most common types of injury were muscular lesions, followed by lesions of the skin (abrasions, lacerations...), ligaments and tendons. In males there is higher risk of muscle injuries than in females, while in females the risk of stress fractures is higher than in males. The risk of injury also varies by event, with a higher risk in the combined events, marathon and long-distance track events. Males have a greater risk than females in the sprints, middle-distances, race walking and jumps[41].

For two of the international championships studied, data collection on athletes' health was extended to the four weeks before the championships[15,18]. It was found that 30% of the athletes participating in these studies reported an injury complaint in this preparation period, including a third who had to decrease their training load and about 4% who could not practice at all. These injury complaints appeared to be overuse injuries mainly because there was a gradual onset and they existed for more than four weeks[15].

Injury rates during the whole athletic season

In a questionnaire-based retrospective study of 147 national-level athletes over about 12 months of training, D'SOUZA[33] reported that 61% of athletes had at least one injury during the season. The locations and types of injuries varied by event, with a high prevalence of shin splints in middle- and long-distance runners, ankle injuries in throwers, and thigh injuries in jumpers[33].

In another questionnaire-based retrospective study of 95 national-level athletes over about 12 months of training, BENNELL & CROSSLEY[34] reported that 76% of athletes had at least one injury during the season, with an incidence of 3.9 injuries per 1000 hours of athletics. The main injuries were stress fractures (20.5%), hamstring muscle injuries (14.2%), and knee overuse injuries (12.6%). Overuse was the most frequent cause (72%). The mode of onset varied by event: more sudden injuries in the

explosive events (sprints, hurdles, jumps and combined events) and more gradual injuries in the endurance events (middle distance, marathon) and background training[34].

In a prospective study over four athletic seasons (1994-1998) of 69 selected French combined event athletes, EDOUARD et al reported 39 injuries in 14 heptathletes and 47 injuries in 18 decathletes. The injury rate per 100 athletes per season for the heptathletes and the decathletes was 33 and 30, respectively. Of the injuries suffered, 41% affected the tendons and 23% affected the muscles. The most common diagnoses were knee tendinopathy (14%), followed by lower leg muscle injuries (13%), thigh muscle injuries (11%), and Achilles tendinopathy (11%). The causes of injuries were mainly overuse (49%) or acute trauma (43%)[22].

In a prospective study of 140 pole vaulters over two seasons, REBELLA et al. reported an incidence of 26.4 injuries per 100 athletes, with ankle sprains representing a third of the cases[35]. In a second prospective study of 150 pole vaulters over one season, REBELLA[38] reported an incidence of 7.9 injuries per 1000 athletes-exposure, with most injuries being in the low back pain, hamstring and lower leg.

In a prospective study of 292 national-level athletes over 12 months, JACOBSSON et al reported that 68% of those studied had at least one injury during the season and the injury incidence was 3.6 per 1000 hours of athletics. Of the injuries, 96% were caused by overuse, and 51% evolved for more than 3 weeks. The main locations were the Achilles tendon, the foot and ankle, the thigh and hip and the lower leg. The main complaints were hamstring injury among sprinters and jumpers, Achilles tendonopathy and shin splints among middle-distance runners, and lower back pain among throwers[25].

Conclusion on injury rates in athletics

In light of all these results, it can be first said that international and national athletics federations have promoted and actively participated in the development of the knowledge of injury rates in their sport. We are beginning to identify and detail extent of the problem, especially among elite high-level populations taking part in major international championships, although the data on injuries over the whole season comes from only a few studies using different methodologies. Thus, further epidemiological injury data collections would still seem to be relevant and necessary[3].

Second, we can say that the overall picture that has been developed for elite athletes is that the most common injury problems experienced are hamstring muscle injuries (especially in sprints, hurdles, and jumps), Achilles tendinopathies (in sprints, middle- and long-distances, and jumps), knee overuse injuries (in sprints, middle- and long-distances), shin splits and/or stress fractures (in sprints, middle- and long-distances), ankle sprains (in jumps), and low back pain (in jumps and throws). We can also note that the principal cause of injuries in athletics is overuse.

Step 2: Mechanisms and Risk Factors

With some idea of the scope and extent of injuries in athletics, the next step is to determine the mechanisms that lead to injury and intrinsic and extrinsic risk factors involved[28]. This can be achieved by 1) biomechanical and/or physiological studies on a representative sample of subjects and/or a functional segment in connection with a sport (joint, muscle group, sporting gesture) or 2) prospective studies cohort follow-up with regular collection of biomechanical parameters and/or physiological related to possible occurrences of injuries[42].

Injury risk factors during championships

The epidemiological studies during international athletics championships have reported relevant information about factors associated with injury rates. For example, injury rates vary according to event: higher injury rates are reported in combined event, marathon, middle- and long-distances[40,41]. Male athletes have higher injury rates than females[16,41]. Age also

appears to be a factor, with higher injury rates in athletes over 30 years[16].

Data collection on athletes' health extended to the four weeks before the championships provides improved knowledge in terms of risk factors[15,18]: in a preliminary study of 74 athletes, training volume was associated to higher injury rates[18]; another study with a cohort of 698 athletes showed that an injury complaint in the four weeks before the championships is a significant risk factor for a new injury during the championships[15].

Injury risk factors over the season

Results are less consensual when looking at injuries over the course of the whole season, although some trends have emerged:

- a previous injury appears to be a risk factor for further injuries[25,35],
- the influence of gender was discussed but no consensus has emerged: higher injury risk has been reported both in male[25,33,34] and in female athletes[36,37],
- a lower prevalence among juniors (<20 years) and higher among older athletes has been reported[33,34],
- there is a link between the training load (volume x intensity) and the risk of injury[25],
- the incidence of injuries is lower in athletes training under the eye of a coach compared to athletes training alone[33],
- the maladaptive coping practice of self-blame was found to be associated with increased risk of overuse injuries[26].

The influence of the performance level on injury risk has also been discussed with findings showing variously an increased incidence with increasing level[36], a decreased incidence with increasing level[33], and no influence from the level of the athlete[34].

Given the frequency and incidence of hamstring muscle injuries and their impact, it seems relevant to add specific information on the associated risk factors. Studies on injury rates in athletics show that hamstring muscles injuries are more common:

- at start of the season[43],
- in boys than in girls[44],
- in Masters athletes than young people[44],
- in the 4x400m than 4x100m[44],
- in athletes who had a previous hamstring injury[45],
- if the isokinetic hamstring/quadriceps ratio is less than 60% at 180°/s [43].

Conclusion on injury risk factors in athletics

Some factors seem to be associated with higher injury rates: a first episode of injury, male gender, increased age, participation in certain disciplines. However, knowledge about the mechanisms and risk factors of athletic injuries is still limited. Work in this area should continue through specific studies on populations of athletes, taking into account the differences between disciplines and the large variety of potential risk factors (intrinsic, extrinsic, physical, psychological, social…) and it should probably focus on the most frequent and/or severe injuries, the most at-risk populations and the most injury-prone disciplines. International and national athletics federations can have a role in promoting and/or coordinating these efforts.

Step 3: Design of Injury Prevention Measures

As knowledge of injury risk factors develops, the third step in the process is to imagine/develop injury prevention measures that could reduce the risk and/or severity of injuries.

Main ideas for injury prevention in athletics

Based on a non-exhaustive review and brainstorming between the co-authors, we have determined that prevention measures may aim to improve:

- physical conditioning of athletes for improved sensorimotor control (stretching, muscular strengthening, particularly eccentric, proprioceptive, balance, increased resistance to fatigue...);
- technical movement and biomechanics to avoid technopathies and/or technical mistakes that may result in injury;

- lifestyle (improved recovery, sleep, and/or nutrition...);
- sports equipment and rules (modification of rules to improve safety, changes in competition schedules according to weather conditions, the circadian cycle...);
- psychological approach (mental preparation, mental imagery, psychological follow...);
- coordinated and consistent medical care of athletes (medical staff, early and correct care of injury, athletes' health monitoring...).

Examples of prevention

Efforts have been focused on improving the physical condition of athletes with physical training programmes to improve flexibility, muscle strength, sensorimotor control. Muscle strengthening exercises dedicated to athletes, including eccentric exercises targeting the hamstrings have been proposed[46,47].

Another focus has been on improvement of technical movements, as in the highly technical disciplines (for example the pole vault and hurdles) the mastery of movements and some vigilance would appear a sensible part of injury prevention efforts. Teaching programmes for coaches have been implemented by different national federations in order to equip them, and their athletes, with the best knowledge in this area[35].

The Medical Commission of the French athletics federation, with the assistance of an expert trainer, developed a programme entitled "Decathlon of Injury Prevention" to prepare athletes for the practice of athletics and prevent the most common injuries in athletics (available at the following link: http://www.athle.fr/asp.net/main.html/html.aspx?htmlid=4175), but no information about its effectiveness for reducing injury risk and/or severity is available.

To prevent severe or fatal injuries in the pole vault and throws, competition regulations and field official education have been modified and adapted[48]. The medical services at competitions – very well organised for the high level (national and international), but more uncertain because of lack of means for the lower levels – could also be more involved in injury prevention[48,49].

In a reflection on the care pathways and interactions between stakeholders around the injured athlete we agreed that for optimal care, regular communication between all stakeholders (coach, physical trainer, manager and club director, sports federation, doctor, physiotherapist, osteopath, psychologist, agent / manager, family, guru...) is needed. This, of course, is under the condition that medical confidentiality is maintained and treatment is coordinated by the physician[50,51].

Finally, a model for a national-level organisation of sports has been developed by the Swedish athletics federation with the aim of reducing/preventing overuse injuries. This model includes: diminished organisational hierarchy (participatory safety policy design is introduce by actors from different sectors), the introduction of a safety surveillance system (routine for injury data collection), and the provision of an open forum for safety issue discussion (discussion between actors form different sectors)[52].

Conclusion on the design of injury prevention measures for athletics

The collection and development of ideas for injury prevention in athletics should continue based on the knowledge gained from steps 1 and 2 of the injury prevention sequence. This should include multidisciplinary brainstorming, and/or a systematic review of prevention measures in other sports. Again, international and national athletics federations can have a role in promoting and/or coordinating these efforts.

Step 4: Validation of Prevention Measures

The fourth and final step in this process will be to assess and validate the effectiveness of the prevention measures and/or strategies developed by observing any reductions in the incidence and/or severity of injuries. This can be achieved by epidemiological studies, or preferably by randomised clinical trials[27].

Evidence-based injury prevention measures in other sports

In other sports, mainly football, injury prevention programmes have been evaluated and their effectiveness reported. A meta-analysis by LARSEN et al. of 25 randomised controlled trials and 26,610 subjects (mainly practicing team sports) covering 3,464 injuries reported an overall favourable impact of injury prevention programmes, especially muscle strengthening programmes[53]. For example, in football, the FIFA 11+ programme consisting of strengthening exercises, balance and coordination work was developed and validated scientifically, before being rolled out to all football players[54,55]. In handball, a similar programme was also developed and scientifically validated[56]. Other exercise programmes have been developed and validated specifically to prevent a certain type of injury, such as hamstring muscle injuries[57] or anterior cruciate ligament ruptures[58].

Conclusion on validated prevention measures

Unlike other sports, there is to our knowledge no study available in athletics specifically related to the validation of an injury prevention measure, programme or strategy. This thus represents an important challenge and perspective for athletics injury prevention.

Summary

The prevention of injuries and athlete health are important issues for athletes and all the stakeholders in the sport of athletics. Following the four-step approach of VAN MECHELEN et al. we have described the current state of knowledge on athletic injury prevention and the main efforts of international and national athletics federations in this area. Although understanding has advanced substantially, it is clear that more work needs to be done: the vast majority of scientific publications to date relates to Step 1, injury rates. While more studies should be conducted in this area, the emphasis needs to now turn the other steps in the process.

Specifically, knowledge about the mechanisms and risk factors of athletic injuries is still limited, Efforts for better understanding must be focused primarily on the most frequent and/or severe injuries. In addition, measures and/or prevention strategies have been proposed for certain injuries or more generally for all injuries but so far none of these have been scientifically validated in terms of effectiveness for injury prevention.

The national and international federations that have supported the work in this area to date have played a key role and should be recognised for their efforts. However, it is important that they continue their support, both financial and organisational, to make sure that the sport of athletics is as safe and healthy as possible.

Declaration of interest

The authors declare that they have no conflicts of interest related to this article.

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