Chapter 2

Acute physical activity-related injuries in children

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Abstract

An increase in the physical activity of individuals has many health benefits, but a drawback of an increase in physical activity is the risk of related injuries. To reduce the short- and long-term effects in terms of social and economic consequences, prevention of physical activity-related injuries is an important challenge.

A sequence of prevention model has been proposed that aims to prevent physical activity-related injuries in different steps. The model includes (i) identification of the problem in terms of incidence and severity of injuries, (ii) identification of the risk factors and injury mechanisms that play a role in the occurrence of injuries, (iii) introduction of measures that are likely to reduce the future risk and (or) severity of injuries, and (iv) evaluation of the effectiveness of the measures by conducting a randomised controlled trial (RCT). This review describes what is currently known about all of the various aspects of the sequence of prevention in children (step i–iv).

Introduction

In general, an increase in physical activity has many health benefits: it lowers the risk of obesity, coronary heart disease, type 2 diabetes mellitus, hypertension, and osteoporosis[1-3]. Besides the health benefits, many additional reasons can be given to participate in physical activities, such as sports. These include social interactions, enjoyment, relaxation, and improving self-esteem[3-5].

A drawback of an increase in physical activity is the risk of related injuries, both in adults and children. The physical and physiological difference between children and adults may cause children to be more vulnerable to specific injuries. Results from studies accomplished in adults cannot be used to describe the extent and risk factors for injuries in children. There are physical and physiological differences between children and adults that may cause children to be more vulnerable to other certain injuries than adults. With respect to children, little has been published about sports injuries, especially those associated with growth, such as growth plate fractures, epiphyseal fractures, osteochondrosis dissecans, and traction apophysitis.

Therefore, we will focus only on acute injuries. In recent years, more and more children are undertaking intense training at younger ages or participating in multiple sports, even in a single season. These athletes expose themselves to a greater risk of acute physical activity-related injuries[1]. The magnitude of acute paediatric sports-, recreation-, and exercise-related injuries has been shown in some studies[6-9]. From these, we can conclude that acute physical activity-related injuries in children are becoming a health problem. Although most acute sport injuries are not life threatening, the occurrence of a sport injury can result in pain, disability, and sometimes dysfunction in the short and long term. To reduce the short- and long-term effects in terms of social and economic consequences, prevention of acute physical activity-related injuries in children is an important challenge. The prevention sequence model of van Mechelen et al. (1992) has been regarded as a logical manner in which to study injury[10]. In this model, a four-step approach has been suggested. The model includes (i) identification of the problem in terms of incidence and severity of physical activity-related injuries, (ii) identification of the risk factors and injury mechanisms that play a role in the occurrence of physical activity-related injuries, (iii) introduction of measures that are likely to reduce the future risk and (or) severity of physical activity-related injuries and, (iv) evaluation of the effect of the measures by a randomised controlled trial (RCT) (see figure 2.1).

Finch (2006)[11] has extended this model of injury prevention (see figure 2.1). Once prevention measures have proven effective, research is needed to implement these measures. For that reason, Finch proposed a more comprehensive research framework, i.e. the "Translating Research into Injury Prevention Practice" (TRIPP) framework, which includes 6 steps. The first 4 steps in the TRIPP framework are identical to the 4 steps in the sequence of

Figure 2.1:*The sequence of prevention model as proposed by van Mechelen et al.* [10] *extended with the Finch model* [11] *.*

Step 1:
Establishing the extent of the injury problem

Step 2:
Establishing the etiology and mechanisms of the injuries

Step 3:
Developing and introducing a preventive measure

Step 4:
Assessing its effectiveness by conducting an RCT

Step 5:
Determine how the intervention could best be targeted

Step 6:
Evaluation of the effectiveness of preventive measures in implementation context

prevention proposed by van Mechelen et al. In addition to these, Finch adds 2 more steps in the TRIPP framework, which focus on how to implement the intervention in a real-world context. In TRIPP stage 5, it is determined how the intervention could best be targeted and "marketed" to sports organizations and their participants. TRIPP stage 6 involves the evaluation of the effectiveness of preventive measures in implementation context.

To date, and too often, much has been published about single steps in the sequence of prevention, such as identification of the injury problem (incidence). In this article, we will give an overview of what is currently known about the 4 steps of the model by van Mechelen et al (1992) with respect to injury prevention in children. To do so, a narrative review of the literature was carried out.

Materials and methods

Relevant studies were identified using a computerized search (PubMed and EMBASE). Of these identified studies, references were searched for additional information. Additionally, a search in our personal databases was done. For this review inclusion criteria were papers published in the English and Dutch language between 1990 and May 2007. Keywords used in the search were 'sport injury' OR 'physical activity injury' AND 'children' OR 'adolescents' OR 'youth' in combination with 'incidence', 'risk factors' OR 'prevention'.

Results

The extent of physical activity-related injury problems in children

Injuries cause children unnecessary suffering, pain, and risk, and can be associated with prolonged periods of disability. Besides these short-term effects, there are also long-term effects of injuries. Long-term effects of an injury are particularly frequent after acute injuries to the knee or ankle, which are the most common injuries in children[1,12,13]. Moreover, individuals who have experienced injuries to joints may also be at risk of accelerated development of (secondary) osteoarthritis in adulthood[14,15]. It is also suggested that the long-term effects of injuries sustained at a young age have a negative influence on participation in health-enhancing physical activities and sports[16,17]. To reduce the short- and long-term effects of injuries in children, it is important to know what the extent of the problem is. Quantifying injury prevalence and incidence (step 1 in the sequence of prevention) includes aspects such as who is affected by injuries (general and sport-specific occurrence), where do injuries occur (anatomical location), and what is their outcome (injury type, severity, and economic cost). Step 1 in the sequence of prevention focuses on the descriptive epidemiology of physical activity-related injuries.

General injury incidence

Conn et al. (2003) characterized sports- and recreation-related injury episodes in the US population[7]. They collected their data with a face-to-face Household survey, which was conducted by the National Centre for Health Statistics. Data were collected from an adult member of the family regarding all medically attended injury episodes occurring in the previous 3 months for each person in the family. A parent or guardian responded for children under age 18. An injury was defined as an injury that required treatment by a health care professional, either in person or by telephone. Annually, an estimated 7 million Americans received medical attention for sport and recreation injuries (25.9 injury episodes per 1000 persons). The highest average annual sports and recreation injury episode rates were found in children aged 5–14 years (59.3 per 1000 persons). A survey of sport participation and sport injury in Calgary, Alberta, revealed that 1787 out of 2721 high school students (grades 10–12; ages 14–19) reported at least 1 sports injury per year (65.7 injuries per 100 adolescents per year)[18]. The injury rate accounting for only those injuries that required medical attention (i.e. physician, physiotherapist, athletic therapist, etc) was 40.2 injuries per 100 adolescents per year. The injury rate including only those students with injuries where "play was stopped and went to a hospital" was 8.1 injuries per 100 adolescents per year. Another study collected data on the medically treated sports-related accidents and injuries in children below the age of 16 in Bergen, Norway, in 1998[6]. They included all children (<16 years old) who received medical treatment at the Accident and Emergency Department (AED) and those admitted to the hospital. They registered a total of 7.041 new injuries and concluded that injuries in need of medical treatment at the AED or the hospital had a yearly incidence of 9% for children under the age of 6 years and 13% for children aged 6-15 years. In the Netherlands, 43% of the injuries were found in children and 31% of these injuries were medically treated[9]. In fact, physical activity-related injuries among children are even more frequent than injuries due to other types of accidents [19]. Although the data from the different studies and different countries are difficult to compare, they clearly show that the number of physical activity-related injuries are high.

Sport-specific injury incidence

Many studies concentrate particularly on individual participant groups. The researchers focus for example on a single team, a single sport, or a specific country or region. Caine et al. (2006) provides an overview on descriptive epidemiology as it applies to paediatric sport-related injuries[20].

The data show incidence rates for girls and boys. Incidence rates for boys are given for baseball, basketball, cross-country running, football, gymnastics, ice hockey, rugby, soccer, and wrestling. Girls' incidence rates are given for basketball, cross-country running, field hockey, gymnastics, soccer, softball, and volleyball. The highest rates of injury per 1,000 athletes at risk are reported for boys in cross-country running, soccer, baseball, and football, and vary between 2.0 and 17.0. The highest rates for girls are in cross-country running, softball, and gymnastics, and vary between 3.5 and 19.6 (see table 2.1). When taking the sport exposure of the athletes into account, the highest rates of injury per 1000 hours of exposure time are reported for boys in ice hockey, rugby, and soccer, and vary between 2.3 and 34.4. For example, for boys in soccer, the incidence rate varies between 2.3 and 7.9. The highest rates of injury for girls are in soccer, basketball, and gymnastics, and vary between 0.5 and 7.9 (see table 2.2). Emery et al. (2006) reported injury rates by sport activities in Calgary, Alberta[18]. The top 6 injuries were injuries in boys and girls caused by wrestling, gymnastics, hockey, football, soccer, and skateboarding, varying between 31 and 54 injuries per 100 participants per year. They concluded that the proportion of most serious injuries reported was the highest in basketball (12.7%), hockey (10.9%), soccer (10.8%), snowboarding (8.1%), and football (8.1%). Most of the sports in which boys and girls sustain injuries involve a high rate of physical contact, jumping, sprinting, or pivoting activities.

Table 2.1: *Highest injury rates per 1,000 athletes at risk for boys and girls [20].*

Boys		Girls	
Sport	**Injury rate (ranges)**	**Sport**	**Injury rate (ranges)**
Cross country running	10.9 - 15.0	Cross country running	16.7 - 19.6
Soccer	4.3 - 17.0	Softball	3.5 - 10.0
Baseball	2.8 - 17.0	Gymnastic	8.5
Football	2.0 - 16.2		

Table 2.2: *Highest injury rates per 1,000 hours exposure time for boys and girls [20].*

Boys		Girls	
Sport	**Injury rate (ranges)**	**Sport**	**Injury rate (ranges)**
Ice hockey	5 - 34.4	Soccer	2.3 - 7.9
Rugby	3.4 - 13.3	Basketball	3.6 - 4.1
Soccer	2.3 - 7.9	Gymnastic	0.5- 4.1

Anatomical location

Obviously, the identification of commonly injured anatomical sites with a high risk of injury is important targets for preventive strategies. Several studies indicate that the most frequently injured body parts are the lower extremities. The ankle proved to be the most affected part of the body, followed by the knee. Upper-extremity injuries are less common and often include shoulder, elbow, and wrist injuries in sports such as judo, gymnastics, and snowboarding, although the rank order varies by sport[7,18,20,21,22].

Injury type

In addition to the identification of injury rates and injury risk sites, the identification of common injury types also provides an indication on methods by which related risk factors and preventive measures can be tested. The most common types of injuries reported across physical activities are sprains and (or) strains and contusions. Depending on the type of activity, participation level, and gender, these are followedn by laceration, fractures, and inflammation[7,20,23].

Severity of injuries

The severity of injuries can be defined on the basis of 6 criteria: nature of the injury, duration and nature of treatment, sporting time lost, working time lost, presence and degree of permanent damage, and costs. The duration of sporting time lost gives the most precise indication of the consequences of an injury and is often used in the literature on paediatric physical activity-related injuries. The seriousness of injuries can be classified by the national athletic injury registration system (NAIRS). Injuries can be divided into 3 different classes, i.e. minor injury (1-7 days sporting time lost), moderate injury (8-21 days sporting time lost), and serious injury (more than 21 days sporting time lost or permanent damage)[10,20]. Another common classification of injury severity is the abbreviated injury scale (AIS). The AIS uses 3 different grades, code 1 (athlete's return within 1 week to his or her activity), code 2 (absence for more than 1 week but less than 1 month), and code 3 (absence for more than 1 month)[22]. The measurement of severity of the injury by assessing the duration of sporting time lost has some limitations. Subjective factors such as personal motivation, peer influence, and coach stimulation could determine if and when athletes return to play, and thereby influence the injury severity. The data available on severity of injuries indicate that most pediatric physical activity-related injuries are relatively minor as indicated by time loss[20].

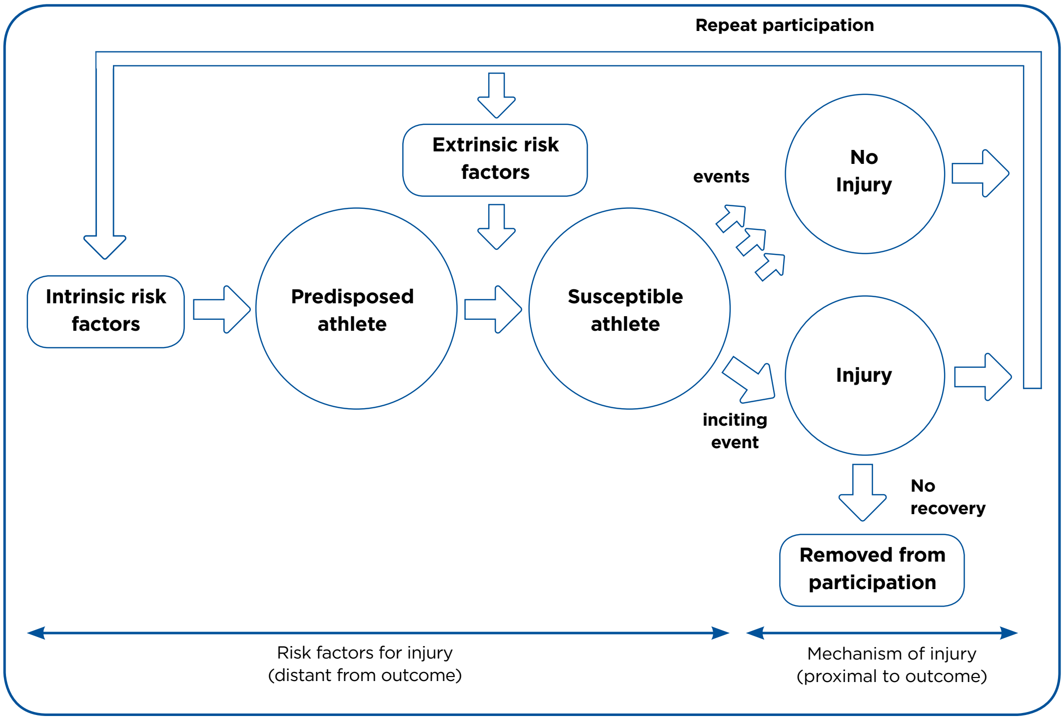
Economic costs

The expenses of injuries can be very high. They include medical costs, such as medical and hospital services, work-loss costs, such as parents' lost wages and fringe benefits or and employer's' lost productivity, other costs, such as police and fire department costs, and the cost of one's altered quality of life. Even though most injuries in children are not severe, their economic burden is substantial. According to the National Youth Sports Safety Foundation the costs mounted up to almost USD 26 billion for sports-, recreation-, and exercise-related injuries to youths aged 0–14 years in 1998. de Loës et al. (2000) reviewed data on knee injuries across 12 sports in children aged 14-20 years [24] . They found the mean medical costs to be USD 1097 per knee injury for males and USD 1131 per knee injury for females. Obviously, to decrease these high costs, programmes must be developed to prevent as many physical activity-related injuries as possible.

Risk factors for physical activity-related injuries in children

A critical step in the sequence of prevention as postulated by van Mechelen et al. (1992) [10] is to establish the causes of physical activity-related injuries. This includes obtaining information on why a particular athlete may be at risk in a given situation (risk factor), and how injuries are caused (injury mechanism). The goal of defining risk factors and mechanisms of injury is to use this information for the development of effective preventive measures. Risk factors can be divided into 2 categories: characteristics related to the individual (intrinsic risk factors), and characteristics that are not related to the individual (extrinsic or environmental risk factors). Intrinsic factors include age, sex, and body composition. Extrinsic risk factors include sports factors, protective equipment, and sports equipment. The inciting events are the third link in the chain that causes an injury. The description of the inciting events can be grouped into 4 categories: (i) vital aspects of the playing (sports) situation (the situation described from a sports-specific point of view), (ii) athlete and opponent behaviour (a qualitative description of the athlete's action and interaction with the opponent), (iii) gross biomechanical characteristics (description of whole-body biomechanics), and (iv) detailed biomechanical characteristics (description of joint or tissue biomechanics)[25]. A dynamic model for injury causation has been developed by Meeuwisse et al. (2007)[26]. This model clearly shows that an injury is the result of a complex interaction between intrinsic and extrinsic risk factors and is not exclusively caused by the inciting event that is generally associated with the onset of injury (see figure 2). In conclusion, internal risk factors, external risk factors, and inciting events are all associated with the onset of an injury. Below, we describe what is known about the intrinsic risk factors, extrinsic risk factors, and the inciting events for physical activity-related injuries in children.

Figure 2.2: *A dynamic, recursive model of etiology in sport injury, based on Meeuwisse et al (2007)*[26].



Intrinsic risk factors

Many studies have been performed to investigate intrinsic risk factors in relation to age, gender, previous injury, aerobic fitness, and body composition and skill level. The following are some of the most important conclusions.

Age

Some sports injuries only occur in children. For example, slipped capital femoral epiphysis occurs in specific age ranges of children (10–15 years) and Osgood– Schlatter's only occurs in older children. However, no clear association between age and acute types of injuries (e.g. sprains and strains) or location of injury has been found. This is mainly caused by the various research methods used in the different studies. They differ in terms of sport, age ranges, and types of injuries investigated. Furthermore, many studies focused on a narrow age range, which makes it difficult to observe a possible association between age and injury incidence[27,28]. Additional research is needed with groups with broad age ranges to allow conclusions on injury incidence and age.

Gender

It is clear that girls are at increased risk of suffering anterior cruciate ligament (ACL) injuries. Many explanations have been given for why girls suffer more serious knee injuries than boys. These include anatomical, hormonal, and neuromuscular factors[28]. Boys have a greater risk of general injuries as they may be more aggressive, have larger body mass, and experience greater contact compared with girls in the same sports[27]. Boys are also more likely to participate in vigorous exercise and sport and therefore have greater chances for exposure to injuries[29].

Previous injury and inadequate rehabilitation

Strong evidence is provided in the literature that previous injuries combined with inadequate rehabilitation are a risk factors for re-injury of the same type and location, especially in the ankle[30-32]. A previous injury may lead to an increased risk of sustaining future injury, possibly due to muscular weakness and imbalance, impairment of ligaments, and fear of re-injury[28].

Aerobic fitness and body composition

Diminished aerobic fitness may cause fatigue, leading to reduce protective effect of musculature on skeletal structures, impairment of perception reduction of attention, and motivation. Unfortunately, studies reporting on the association between aerobic fitness and injury used different methods to characterize aerobic fitness. This makes it difficult to compare findings[28,29]. Studies about the association between body composition and injury are also unclear and even conflicting. These studies used many different techniques to represent body composition, such as height and mass, lean muscle mass, body fat content, and body mass index (BMI)[28]. Taller and heavier athletes may be more susceptible to injury due to greater forces being absorbed through soft tissues and joints[27]. Additional investigations that use a common measure to represent aerobic fitness and body size are therefore needed to draw firm conclusions. A marginal comment must be made. The relationship between body size and performance variable is not necessarily linear, thus it is appropriate to use a scaling technique based upon the allometric or power function model[33].

Skill level

Several studies have analyzed the relationship between skill level and injury. Skill and technique play an important role in the aetiology of physical activity-related injuries, especially in events that place a high demand on coordination and balance. Beginners, who are less skilful and experienced, generally sustain more injuries[34]. Besides that, injury incidence is higher during competition than during training sessions. This suggests that athletes are more prone to aggressive, risk-taking behaviours during competition, which may in turn increase the potential for injury.

Extrinsic risk factors

Extrinsic risk factors comprise rules, coaching, use of protective equipment, and environmental factors. However, few data are available on injury incidence and such extrinsic risk factors in children. For example, in adult athletes, environmental factors such as playing surface play a role in the outcome of injuries. Arnason et al. (1996) have reported an increased incidence of injury in elite soccer on artificial turf compared with grass and gravel[35]. More injuries are likely to occur on artificial turf because of its stiffness and increased frictional force at the shoe-surface interface. However, these results were found in elite athletes where grass fields are very well maintained. Grass surfaces that are not maintained and become mud or hard dirt could have stiffness and frictional forces that are closer to or even more extreme than artificial turf. The effect of playing surfaces on injuries in children should therefore receive additional investigation. The association between shoe type and ankle injury is controversial, because this has not been investigated adequately. Shoes offer external support, but factors other than support, e.g. traction, limitation of joint mobility, and effects on proprioceptive input, also need to be investigated in future studies on shoe type and ankle injury incidence[28]. Another external risk factor is training errors. Training errors, such as initiating physical activity too suddenly, play a significant role in outcome of injuries in sports.

Although some studies have focused on internal and external risk factors for physical activity-related injuries, our understanding of injury causation is very limited. Many risk factors have been associated with injury incidence, but little agreement with respect to the conclusions can be drawn. This is partly because of limitations in study design and the statistical methods used to assess the results. Moreover, different sports have been studied in which risk factors may vary depending on the sport so that general conclusions are difficult to draw. We only can conclude that strong evidence is provided in the literature for previous injuries combined with inadequate rehabilitation. Previous injury combined with inadequate rehabilitation is a risk factor for re-injury of the same type and location.

Inciting events (injury mechanism)

An examination of the literature to evaluate how the term "injury mechanism" is defined shows that biomechanically oriented descriptions dominate, although to different levels of detail. When considering the prevention of injuries, information about athlete and opponent behaviour may be more relevant than a biomechanical description. If patterns can be established in the events leading to an injury situation, this information can be easily applied to prevent injuries[25]. A number of different methodological approaches can be used to describe the inciting events for sports injuries. These include interviews of injured athletes, analysis of video recordings of actual injuries, clinical studies, in vivo studies, cadaver studies, mathematical modelling and simulation of injury situations, and measurements or estimation from "close to injury" situations[3] . Krosshaug et al. (2005) reviewed these different research approaches and concluded that, for most injury types, one approach alone will not be sufficient to describe all aspects of the injury situation[36]. It is therefore necessary to combine a number of different research approaches to describe the injury mechanisms fully.

Development of an intervention programme to prevent physical activity-related injuries in children

The third step in the sequence of prevention is to introduce measures that are likely to reduce the future risk and (or) severity of physical activity-related injuries. To develop preventive measures that are likely to be effective and will be used by the target population, the entire path that leads to injury needs to be known. A researcher needs an extensive answer to the question "what is causing this injury?"

In recent years, health promotion has attempted to address the complexity of many health problems by applying community-based approaches[35,37]. Physical activity-related injuries, with a broad range of injury types, lend themselves to community-based approaches. Towner and Dowswell (2002) examined 10 community-based injury prevention programmes that have targeted childhood injury prevention[38]. Eight of the studies were considered partially effective and two were inconclusive. However, none have used a randomised controlled design. The evaluations of community-based injury prevention programmes have many shortcomings[39].

Because physical activity-related injuries in children are becoming a health problem, it is important to focus on the development of an intervention programme to prevent injuries in children. Since an increasing number of children are attracted to unorganized sports activities and individual sports, programmes aimed at preventing physical activity-related injuries in youth should focus not exclusively on organized sports, but also on unorganized physical activities. Schools provide a good possibility for communicating with a large population of young people. By obligation, every child visits schools on a daily basis, for this reason schools have the potential to become important settings for preventive activities. Although schools have this potential, evidence on the effectiveness of a school-based programme for injury prevention is extremely scarce. To our knowledge, the only school-based study in the area of physical activity-related injury prevention in children concerns a trial conducted by Backx (1991)[21] . This study, concerning secondary school pupils (12-18 years), indicates that knowledge about injury prevention can be improved (23% explained variance). However, the attitude change within a period of 1 year was small (4% explained variance). This changed attitude of the pupils was suggested as having a favourable effect on injury incidence. Unfortunately, there is a lack of research from which evidence regarding the effectiveness of school-based childhood injury prevention programmes can be obtained. There is a clear need to increase the efforts on developing such evidence-based studies.

Taken together, the development of an intervention programme to prevent physical activity-related injuries must focus on the risk factors and the injury mechanisms as identified in the literature. When the intervention programme has been developed, schools can be used to reach a large population of young people. It is likely that schools have the potential to become important settings for prevention programmes of physical activity-related injuries in children.

Assessing the effectiveness of preventive measures

Step 4 of the sequence of prevention is an evaluation of the preventive measures that arise from step 3. Ideally, the preventive effect of the measures should be evaluated by undertaking a high-quality, randomised controlled trial (RCT). However, one should be aware that RCT's only provide a view of the efficacy of an intervention, i.e., whether or not this intervention works under ideal conditions.

What do we know about the effect of injury prevention programmes in children? Few RCT's of preventive measures for physical activity-related injury have been reported in the international literature. The evidence that injury prevention programmes reduce the risk of physical activity-related injuries in children is weak and is primarily based on cohort studies for specific injuries in specific sports. Emery (2005) showed that only 4 RCT's were performed in a youth population[40]. These studies conclude that sport-specific training programmes can reduce the incidence of specific injuries within specific sports[41-44]. No studies are available on the effectiveness of global prevention strategies in children, where the greatest public health impact could be realized. It would be of interest to determine what the effect is of a school-based intervention programme on physical activity-related injuries in children. In these studies, issues such as acceptability, compliance, cost effectiveness, and long-term adherence to the preventive measure should be included.

Discussion and conclusion

The published incidence of physical activity-related injuries in children varies widely across studies and sports. Although all studies are informative, it is difficult to draw general conclusions. One of the reasons is that no clear definition on injuries exists. In general, an injury is a collective name for all types of damage that can occur in relation to sporting activities. Various studies on injury incidence define the term injury in different ways. Obviously, the various definitions will influence the incidence rates measured in the different studies. Definitions of injuries include criteria such as presence of a new symptom or complaint, decreased function of a body part, or decreased athletic performance. If injuries are only recorded through medical channels, a large percentage of serious injuries will be observed and less serious injuries will not be recorded; thus, only part of the total physical activity injury problem is revealed. One could describe this as the "tip-of-the-iceberg" phenomenon[10,45]. A second reason for different incidences reported is that no common agreement exists as to how injury incidence is expressed[40,46]. Even if a single uniform definition of "injury" is applied, the need remains to establish a uniform agreement on how injury incidence is expressed. Injury incidence refers to the number of new injuries during a particular period of time (e.g., 1 year). One method to express incidence rates (the risks of injuries) is to divide the number of new injuries by the number of population at risk. Another method to express incidence rates is to calculate the incidence of injuries in relation to exposure (in days, hours, or by sporting event). Obviously, all of these different parameters make it difficult to draw general conclusions on injury rates based on published data in the literature. We realize that studies depend on local situations and often aim to investigate problems in specific sports. However, general methodologies are required to be able to compare the results of the different studies. From the data presented in this review, it can be concluded that a drawback of increased physical activity is that the frequency of physical activity-related injuries will also increase. To reduce short- and long-term effects in terms of social and economic consequences, the prevention of physical activity-related injuries in children is an important challenge. It is essential to identify the injury problem and risk factors specifically in children and to develop and evaluate preventive measures that are expected to reduce physical activity-related injuries in children. Currently, measures that prevent physical activity-related injuries in children are hardly available and little is known about their effectiveness. We feel that it is necessary to develop and evaluate school-based intervention programmes to diminish the number of physical activity-related injuries in children.

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