CHAPTER 1
General introduction
Physical activity: health benefits and injuries

Individuals benefit from regular physical activity including sport participation, since such activities are related to enjoyment, social interaction, weight management, and maintenance and improvement of health [1-3]. The reported inherent health benefits are many, for instance improved musculoskeletal and cardiorespiratory fitness, and reduced risk of multiple disease states, such as hypertension, cardiovascular disease, diabetes, breast and colon cancer, depression, falls and hip or vertebral fractures [2-5]. Physical inactivity [2, 3, 6] and sedentary behaviour [7, 8] have been identified as important risk factors for all-cause mortality and a large number of diseases. From a public health perspective, both a physically active lifestyle and sport participation have been recommended [2, 5, 8, 9], and policies and plans to enhance a physically active lifestyle have been developed and implemented worldwide [2, 10]. From the perspective of an individual, reasons to participate in sport and physical activity are diverse and relate largely to the reported health benefits. Most reported reasons by Dutch individuals are improvement of physical fitness (69%), weight management (57%), relaxation (55%), and/or improvement of general health (48%) [11].

Although current evidence clearly states that the benefits of being physically active outweigh potential harm [2, 9, 12], attention should be paid to the prevention of injuries related to participation in sport and physical activity (hence forward referred to as ‘sport injuries’) [13]. Sport injuries form a significant health problem at an individual and public health level. Such injuries confront individuals with (temporary) physical inactivity, pain, medical treatment and absence from school or work as possible consequences. At a societal level, the cost related to medical treatment and work absenteeism is substantial. For instance, in the Netherlands, a total of 4.5 million sport injuries annually occur in a population of 12 million individuals who report to be active in sports, with an estimated total cost of 1,500 million euros, including direct medical costs of 520 million euros [14]. Consequently, the prevention of sport injuries is important to maintain and increase a physically active lifestyle and participation in sport throughout the lifespan, and to maximise the related and pursued (health) benefits. Nationwide sport injury prevention programmes have been developed and implemented in the Netherlands, next to public health initiatives promoting physical activity [15, 16].

Preventing sport injuries

Actual on-field sport injury prevention requires large-scale adoption and the correct use of evidence-based preventive measures by the target population [17-19]. To accomplish such a preventive effect, both a wide base of knowledge on sport injury prevention at multiple levels is necessary, as well as a systematic preventive approach [17, 20]. A useful framework for identifying the knowledge and research process necessary to pursue the implementation of effective preventive measures in practice, is the research cycle for health interventions proposed by Tugwell et al. [21]. This cycle states that effective prevention of any health problem is the result of seven consecutive steps, ranging in content from fundamental to practical [22]. These seven steps outline the process of translating scientific evidence into practice. The research cycle has previously been applied to the prevention of ankle sprains in sport [22]. The modified version described in this paper is used as the primary framework for this thesis (Figure 1.1).
Applied to sport injury prevention, the research cycle states that the extent of the sport injury problem (i.e. incidence and severity of sport injuries) and the aetiology and mechanisms of injury needs to be established first (steps 1-2), followed by assessing subsequently the efficacy (step 3), and effectiveness and cost-effectiveness of potential feasible preventive interventions (steps 4-5). The research cycle is then followed by the identification of potential facilitators, barriers and other constructs essential for effective implementation in practice (e.g. compliance with the intervention; step 5), after which implementation and evaluation of the impact of preventive interventions in a real-world sport setting concludes the cycle (steps 6-7).

In line with the translational research cycle, two conceptual models developed within the field of sport injury prevention emphasise the relevance of a thorough evidence base and of research at multiple levels, that is, the ‘sequence of prevention’ of sport injuries of van Mechelen et al. [23], and the ‘Translating Research into Injury Prevention Practice’ framework (TRIPP) of Finch [17]. Both models identify epidemiological data on the injury problem, and evidence on the efficacy and effectiveness of preventive measures as the basis for sport injury prevention programmes. In addition, the TRIPP-model underlines the importance of research into current preventive behaviours and its determinants, barriers and facilitators for the uptake of preventive measures, and the implementation and evaluation of interventions in real-world sport settings [17]. This requires a structured implementation plan and implementation efforts at various levels [20, 24]. As such, the research cycle captures the research process necessary to pursue the implementation of evidence-based preventive measures.
From evidence...

Following the translational research cycle, the majority of evidence in sport injury prevention is on the incidence and aetiology of sport injuries (steps 1-2) [25]. Evidence on what works is also available. Numerous studies have evaluated the efficacy and (cost-)effectiveness of preventive interventions on the risk of sport injuries (steps 3-5) [25-31], indicating that such injuries can be prevented in real-world sport settings if evidence-based preventive measures and programmes are adopted and effectively used by the target population (e.g. athletes, coaches, sport federations, and other stakeholders; steps 6-7) [17, 19, 24]. This, in general, requires a change in the preventive behaviour of the target population within the sport injury context achieved through implementation efforts [17, 24, 32, 33]. However, few sport injury prevention studies (an estimated 1% of all studies) have been targeted at the implementation and evaluation of on-field intervention programmes related to steps 6 and 7 of the research cycle [25].

Large-scale adoption and correct use of effective sport injury preventive measures are still considered major challenges [19, 32, 34], and available data on sport injuries in the population substantiate a suboptimal use of effective preventive measures in practice. For instance, in the Netherlands, the overall sport injury risk has been shown to rise over the years [14]. Considering this, additional research is warranted with a focus on the final steps of the research cycle to increase the evidence base on effective implementation [17, 19, 34, 35]. Questions may be raised, however, whether (i) sufficient evidence is available regarding each step of the translational research cycle (Figure 1.1), and whether (ii) the available evidence base on sport injury prevention can effectively be translated to a practical context.

...to practice?

Actual sport injury prevention at a population level is not only determined by evidence on the efficacy and effectiveness of preventive measures, but is also a function of the actual uptake of such measures. Relevant knowledge on effective injury preventive measures needs to be translated in such a way that the target population is reached, and will implement these evidence-based measures into their daily practice [17, 24]. This is influenced by multiple interrelated contextual factors within a specific target group and sport setting [17, 19, 35]. As stated by Finch [35], real-world implementation of injury preventive interventions and evaluation of their effectiveness needs to take into account the sport injury context in which they are introduced, and consider the best method to translate this knowledge to reach the target population. Potentially relevant strategies to translate knowledge on effective preventive interventions to practice include education, contextual modifications, and rule and regulation changes [33, 35-38]. It is recognised that a combination of multiple strategies, implemented at various intervention levels (e.g. at an individual, club, or sport association level) is more effective to support and strengthen sport injury prevention efforts in real-world sport settings [24, 35, 38]. Evaluation of the effectiveness of various strategies to translate knowledge on evidence-based preventive measures to practice is needed.
Objectives and outline of this thesis

The main objective of this thesis is to gain insight into the effectiveness of strategies to translate and implement available evidence on sport injury prevention to broad practice, and as such promote actual sport injury prevention. This can facilitate and support the uptake and (correct) use of effective preventive measures in real-world sport settings to establish effective sport injury prevention at the population level.

The first two chapters describe systematic reviews that focus on summarising available evidence on intervention strategies used in sport injury prevention in general, and on neuromuscular training to prevent ankle sprains, respectively. This relates to steps 3-5 of the translational research cycle (Figure 1.1), aimed at gaining insight on what works in sport injury prevention. Chapter 2 describes a systematic review aimed at identifying and categorising intervention strategies for the prevention of sport injuries evaluated in the scientific literature, as well as to identify potential intervention strategies that have not yet been evaluated (i.e. potential knowledge gaps). Potential intervention strategies range from those primarily targeted at behavioural modification on the part of an individual (e.g. voluntary use of personal protective equipment, or specific training programmes) to those predominantly based on contextual modifications \(^{33, 36-38}\). This review aims to facilitate future sport injury prevention efforts by identifying possible strategies to choose from, given a specific injury problem and a sport context. The identified potential knowledge gaps on sport injury prevention may guide future research in this field. In Chapter 3 studies on the effect of neuromuscular training programmes (NMT) as a preventive measure for ankle sprains in sport, are evaluated to identify essential components and contexts of effective NMT programmes. This systematic review is included as an example of how available evidence can be used to extract additional information on effective intervention components and on contexts in which interventions have shown to be effective, which may be helpful to develop effective and adoptable interventions, and as such increase the uptake of effective interventions.

As a next step, evidence on what works needs to be translated to and implemented in everyday life. This refers to the final implementation and evaluation steps of the research cycle (Figure 1.1, steps 6-7). Chapters 4-6 describe effect and process evaluations of three nationwide interventions that were implemented in the Netherlands as part of (inter)national policies on sport injury prevention. The interventions aim to increase the broad uptake of evidence-based preventive measures in real-world sport settings, using different intervention strategies: (i) rule modification in soccer to promote shinguard use (Chapter 4), (ii) a nationwide intervention to increase helmet use in skiers and snowboarders based on health communication (Chapter 5), and (iii) eHealth as a practical tool to increase the use of an effective NMT programme to prevent recurrent ankle sprains (Chapter 6).

This thesis concludes with a general discussion of the main findings, methodological considerations, and recommendations for future research.