Chapter 10

General discussion and conclusions

The work described in this thesis involves physical activity-related injuries in children. The main purpose of the iPlay-study, was to develop a school-based programme aimed at prevention of physical activity-related injuries in primary school children (aged 10-12 years) and to evaluate its effectiveness and feasibility. In addition, we analysed within the iPlay-study the injury incidence density, injury severity and costs of physical activity-related injuries. In this final chapter the main findings of the iPlay-study will be discussed including methodological issues, recommendations, and implications for future research.

In order to develop an injury prevention programme the model of "the sequence of prevention" developed by van Mechelen et al. (1992)[1] can be used. This model, described in chapter 1, consists of four steps. Step 1 involves the identification of the physical activity-related injury problem in children, including injury incidence and injury severity. Step 2 involves the identification of risk factors and injury mechanisms of physical activity-related injuries. Step 3 deals with the development of an injury prevention programme based on the findings of step 1 and 2. Finally, in step 4 the effectiveness of the developed injury prevention programme is evaluated. The discussion is written along the lines of this four-step model.

Injury incidence and severity

With respect to the identification of the injury problem in children - step 1 of the "sequence of prevention" - it must be noted that published data on injuries as a result of physical activities in children varies widely. One of the reasons is that the definition of an injury differs in the various publications. An injury can be defined for instance as any new symptom or complaint, as a decreased function of a body part, or as an injury that needs medical attention. Mostly, only injuries recorded through medical channels are reported[1,2]. This leads to registration of severe injuries only and therefore an underestimation of the overall injury problem. Moreover, in most studies, injuries are recorded retrospectively. A retrospective study uses existing data that have been recorded for other reasons than the initial study.

Another reason that published data on physical activity-related injuries in children varies between studies is that no common agreement exists on how injury incidence is expressed. One method to express incidence rates is to divide the number of new injuries sustained in a defined time period by the population at risk, multiplied by 100. A better method to express incidence rates is to calculate the injury incidence in relation to exposure time. Time spent in physical activities is an essential epidemiological variable and allows the expression of incidence rates per 1,000 hours of exposure to physical activities[3]. The latter would enable comparison of incidence rates reported across various publications.

Finally, no clear definition of physical activities exists. Studies on physical activity-related injuries are often restricted to injuries during sport club activities only. Data on injuries occurring during leisure time activities (unorganised sports activities) and physical education classes are often lacking. This leads to an underestimation of the actual number of injuries

because only organized sports injuries are reported. As a great part of young children's physical activities consists of leisure time activities outside sport, leisure time injuries should be included in studies on injury incidence in young children. Commonly accepted definitions in the field on what an injury is, how injury incidence is presented, and which physical activity-related injuries are included would allow comparing future studies on injury incidence and injury severity.

In a prospective cohort study - i.e. the iPlay-study - we investigated the injury incidence density and severity occurred during the entire spectrum of physical activity modalities such as sport, leisure time and physical education activities (chapter 4). Injuries as a result of physical education classes, organised sport activities, and leisure time activities were prospectively registered during the school year 2006-2007. Not only medically treated injuries were taken into account. An injury was recorded if the child at least had to stop his/her current activity. We found that the overall injury incidence density in 10-12 year old children was 0.48 per 1,000 hours of exposure (95%CI: 0.38-0.57). Most of these injuries occurred during organised sport activities and involved lower extremity injuries that were caused by missteps or twisted motions.
In the iPlay-study we found that bruises were most commonly reported (43%), mainly occurring during leisure time activities and frequently leading to upper extremity injuries. Ligament sprains and fractures were also commonly reported, especially as a result of organized sports and leisure time activities (chapter 4).
Of all injuries, 40% required medical treatment. Children mostly visited the general practitioner when they were injured. Half of the children who visited the general practitioner were referred to an emergency department or outpatient clinic, the other half were treated by the general practitioner. Seven percent of the children visited the emergency department directly (chapter 5).
The iPlay-study revealed that 68% of the injuries resulted in absence from sports participation. Sport absence of 1 week (minor injuries) was reported in 45% of the children, 29% resulted in an absence of 2 weeks (moderate injuries) and 26% resulted in an absence of 3 weeks or more (serious injuries). School absence was reported in 14% of all injuries, with a mean loss of 1.8 (SD 1.3) school days per injury (chapter 4).
The mean total costs as a result of an injury in children were 188 ± 317€. The mean direct (i.e. medical) costs were higher than the mean indirect (i.e. absence of parent from work) costs, 131 ± 213€ and 57 ± 159€ respectively. The highest costs were found for upper extremity and leisure time injuries (chapter 5).

Little relevant literature is available on the physical activity-related injury problem in children in the Netherlands. One study presented an injury incidence density of 1.3 sport-related injuries per 1,000 hours sport participation in Dutch children aged 4-17 years old[4]. The iPlay-

study reported a lower injury incidence density, probably because our study focused on children aged 10-12 years and it is known that particularly children older than 13 year are at high risk[5]. The difference in injury incidence density can also be explained by the difference in physical activity definition between the iPlay-study and the study of Schmikli et al.[4] The iPlay-study included all modalities of physical activities (sport, leisure time and PE class activities) and not only sports activities.

In the iPlay-study, 104 physical activity-related injuries in 996 Dutch children were reported during one school year. Approximately 588,000 children in the age of 10-12 years are living in the Netherlands[6]. Assuming that the iPlay- study sample is a representative sample of the Dutch population of children aged 10-12 years old, one can estimate that during one school year about 61,400 injuries occur as a result of physical activity-related activities. With a mean total costs of an injury reported at 188 € this means that the costs of physical activity-related injuries in 10-12 years old is annually about 11.5 million €. The mean total costs of 11.5 million € include direct (8.0 million €) and indirect costs (3.5 million €).

Compared to other injury categories, such as home- and traffic-related injuries, most injuries occurred during sports activities. Annually, 1.4 million sport-related injuries need medical attention. For home- and traffic-related injuries respectively 1.2 million and 290.000 medically treated injuries occur[7]. The direct and indirect costs as a result of sport-related injuries take a second place compared to home- and traffic-related injuries. Home-related injuries are injuries with the highest costs for the society (€ 2.1 milliard)[7]. The total costs as a result of sport-related injuries are about € 590 million[8].

Injury prevention lessons at primary schools may reduce physical activity-related injuries in children and thus the associated costs. Furthermore, such programmes may also prevent additional injuries and costs in adulthood, because children participating in injury prevention programmes may become more aware of injury prevention measures and conditions, which may lower the risks for injuries.

Furthermore, injury prevention lessons are important because children may lose their enthusiasm for participating in physical activities through negative associations with injuries[9]. When physical activity-related injuries are prevented, children may be more motivated to continue participating in physical activity. This is important because physical activity has many health benefits[10].

Risk factors and injury mechanisms

An injury can be related with internal risk factors and/or external risk factors and/or an inciting event (mechanism of injury)[11,12]. Identification of these risk factors for injuries is used as a leading guide for injury prevention programmes (step 2 of “the sequence of prevention” model).

Injury risk factors can be derived from the literature. Unfortunately, the strength of the evidence for risk factors of injuries in children is very limited, mainly as a result of differences in

research design, measurements used to assess exposure and injuries, and differences in risk factors and type of sports assessed in the studies [5] .

Risk factors can also be assessed in consultation with the end-users of the injury prevention programme. In order to develop the iPlay-programme, the Intervention Mapping protocol[13] was applied (Chapter 3). This protocol states that focus group interviews with end-users - i.e. schoolteachers - about the injury problem and risk factors are necessary to make sure that the injury prevention programme is acceptable for the end-users and feasible for implementation. Only an injury prevention programme that is adopted by the end-users can be effective in preventing injuries.
In the iPlay-study, focus group interviews were performed with secondary school teachers to determine the injury problem and risk factors for injuries in adolescents. Teachers mentioned in particular the great diversity in neuromotor fitness in children aged 13-15 years old. According to the teachers, the inter-individual difference was an important risk factor to injuries in children. Asking the teachers about the causes of the observed diversity in neuromotor fitness, they argued that an intervention programme should focus on children aged 10-12 years (primary schools) because in this age group the level of fitness is low and should be improved in early childhood. Although this common opinion was not supported by existing scientific literature, it showed that secondary school teachers were hesitant and not motivated to incorporate preventive measures in their classes.
Indeed, the assumed low level of neuromotor fitness in Dutch children aged 10-12 years was confirmed by scores on the neuromotor fitness test completed as part of the iPlay-study (chapter 6). The neuromotor fitness test that was applied measures speed, strength, general coordination, and flexibility. Compared to a study sample of 10-12 yar old children taken in 1980, the current (i.e. 2006) study sample were significant taller and heavier. Body mass index (BMI) was higher in 2006 than in 1980 in all age and gender categories. Furthermore, on all neuromotor fitness tests, performance was significantly worse in 2006 compared to 1980 (chapter 6). These low levels of neuromotor fitness may negatively affect children's daily physical activity levels and in their health status in the long term[14.15] and may pose them at higher risk of injury.

In the literature risk factors are usually described biomechanically, biomedically, or physiologically. When considering the prevention of injuries in children in real life, a behavioural approach is more relevant. One method to develop preventive measures that takes behavioural and environmental determinants into account is the Intervention Mapping protocol that was used to develop the iPlay-programme. To improve injury-preventing behaviour, one needs to change the underlying determinants[16] . The iPlay-programme was based on the Attitude - Social influence – self Efficacy (ASE) model, a basic conceptual model describing determinants of health behaviour. The ASE model is based on the assumption that the in-

tention to engage in behaviour is the result of the attitude, social influence and self-efficacy towards performing the specific behaviour.
The iPlay-programme was thus developed based on literature focus group interviews. As a result of the focus group interviews with teachers, the focus of the programme was shifted from secondary school children (12-14 years) to primary school children (10-12 years). According to the teachers, this age group would benefit more from a prevention programme. The iPlay-programme focused on the prevention of physical activity-related injuries by improving injury-preventing behaviour, determinants of behaviour (knowledge, attitude, social influence and intention), and neuromotor fitness of the children.

Objectives and evaluation of the iPlay-programme

The main programme objectives of the iPlay-programme (step 3 of "the sequence of prevention" model) included; (i) children take fewer injury-related risks, (ii) parents create a safe physical activity environment outside the physical education classes, and (iii) teachers include injury prevention into their usual teaching routine. To achieve these objectives the iPlay-programme included the following programme materials: monthly newsletters about injury prevention for children and parents, monthly posters to be displayed in the classroom addressing the main intervention topics regarding injury prevention, short exercises during the PE class to improve neuromotor fitness, and an informative website accessible for children and parents (chapter 3).

iPlay-effects on injury incidence density

To evaluate the iPlay-programme a randomised controlled trial was conducted. Forty Dutch primary schools, including more than 2,200 children, participated in the study during the school year 2006-2007 (step 4 of "the sequence of prevention" model). We found an overall beneficial effect of the iPlay-programme on total, sport club, and leisure time injury incidence density as well as injury severity. This beneficial intervention effect was not statistically significant most likely due to lack of power. Interestingly, physical activity level was an effect modifier as the iPlay-programme had a larger significant effect in children who were less physically active (chapter 7).

A possible explanation for the larger intervention effect in children who were less active is that these children showed a higher overall injury risk per 1,000 hours exposure than children in the more active group, 0.53 (95%CI:0.38-0.68) versus 0.43 (95%CI:0.31-0.54), respectively. Moreover, focusing on the injury risk during sport club activities, the injury risk in the less active group was 0.91 (95%CI:0.51-0.66) per 1,000 hours sports participation compared to 0.53 (95%CI:0.30-0.76) in the physically more active group.
The higher injury risk in the less active group could partly be explained by baseline differences between the groups regarding body weight status, neuromotor fitness, and injury

preventing behaviour. The less active children were more often overweight at baseline (20% versus 12%) and scored significantly lower on the neuromotor fitness tests (excluding the flexibility test). In addition, they wore less often protective equipment during sport activities and appropriate shoes during sport and leisure time activities. Being overweight, having a low level of neuromotor fitness, not wearing appropriate protection and shoes are potential risk factors for physical activity-related injuries[5,17-19] . Thus, the less active children may have a higher injury risk and therefore may benefit more from an injury prevention programme than physically more active children.

Most of the previously conducted injury prevention programmes focused on highly active children in sport clubs. Based on the findings of the study we feel that injury prevention programmes should focus on all children and in particular the less active children, because they are more susceptible to physical activity-related injuries and may benefit more from a preventive programme. A school-based prevention programme has the advantage that all children can be reached relatively easy.

Furthermore, with the current focus on a healthy lifestyle physically less active children are nowadays stimulated to participate in all kinds of physical activities. Because the iPlay-study showed that especially those children have a higher risk for physical activity-related injuries, injury prevention lessons along side the promotion of physical activities in children is of great importance.

iPlay-effects on injury preventing behaviour and neuromotor fitness

Because the iPlay-programme aimed to decrease physical activity-related injuries by improving injury preventing behaviour and neuromotor fitness we also studied the effects of the iPlay-programme on injury preventing behaviour, the targeted behavioural determinants – i.e. knowledge, attitude, social influence, self-efficacy, and intention –, and neuromotor fitness. In addition, we tested whether the hypothesised behavioural determinants indeed mediated the intervention effect on behaviour (chapter 8).

Results showed that the iPlay-programme did not significantly improve injury-preventing behaviour. Changes in behaviour were significantly mediated by knowledge and attitude. A possible explanation for the fact that the iPlay-programme did not improve behaviour was that the iPlay-programme only improved knowledge and attitude and not the other hypothesised determinants, namely social norm, self-efficacy, and intention. The mediation analyses showed that improved knowledge, attitude, social influence, self-efficacy, and intention were indeed significantly related to changes in injury preventing behaviour.

In summary, we found no significant intervention effect on injury preventing behaviour and neuromotor fitness, and only a significant effect on attitude and knowledge but not on social influence, self-efficacy and intention. However, we found a non-significant but relevant

and substantial reduction in injury incidence density, especially in the less active group. How can this be explained?
A possible explanation is that because behaviour and determinants of behaviour were measured by self-report and not validated questionnaires, the measurements might have not been sufficiently sensitive enough to detect changes in behaviour and determinants of behaviour.
Another possible explanation is that knowledge about injury prevention and attitude towards injury preventing behaviours were directly related to a decrease in injury incidence density. The effects of improved knowledge and attitude scores on injury incidence were not analysed in this study, but are of interest for future research.
Finally, it is also possible that the iPlay-programme improved other variables which are related to injury incidence and which were not measured in the current study.

Methodological issues

The iPlay-study is the first study evaluating a school-based injury prevention programme aimed at preventing physical activity-related injuries in primary school children. During the recruitment of the primary schools, it appeared that 9% of the invited schools agreed to participate in the study, whereas 20% indicated that they were unwilling to participate. The remaining 71% did not respond at all. Schools that were unwilling to participate were not different from participating schools with respect to geographic location (urban / suburban) or professional status of the physical education teacher (certified/uncertified). Comparison of the participating and non-participating schools on other variables (e.g. school resources or staff-to-child ratio) was not possible because information on those variables was lacking. Participating schools may represent a more motivated group. However, such potential self-selection bias was unavoidable in this study. Although the study sample (children) appeared to be representative for Dutch primary school children based on age, gender, ethnicity, and BMI class (chapter 9), one should be careful to generalise the effects of the iPlay -programme to all primary schools as a large scale of the effectiveness might be due to the teachers' motivation.

Study design, participants, and sample size

The iPlay-programme was evaluated in a cluster randomised controlled trial. In this study, individual randomisation was no option due to the school-based nature of the iPlay-programme.
Randomised controlled trials are considered to be of highest methodological quality and therefore are given the highest level of evidence. The iPlay-study included more than 2,200 children from 40 different primary schools. During the study high follow-up rates were achieved.
When calculating the sample size for a cluster randomised controlled trial it is essential to

address clustering. The fact that children within a school are more similar than children between different schools must be taken into account. Sample size calculations are based on many assumptions, for example assumptions on the effect size, power and ICC. Often the exact effect size and ICC are unknown and the power can be set at different values. In our power calculation the effects size was set at 7%, the ICC at 0.10 and the power at 90%.

This ICC was chosen arbitrarily, because no specific literature existed on which this value could be based. However, after analyzing the data of the iPlay-study we found that the cluster effect in our study was much larger than expected, thereby decreasing statistical power.
The randomisation was performed using a computerised random number generator. Despite the randomisation, children in the intervention group differed in ethnicity, SES and BMI and were significantly more physically active than children in the control group. Because of the difference in physical activities, exposure was also different. Therefore, it is important to report injury incidence density; i.e. the number of injuries per 1,000 hours of physical activity participation, as we did in our study.

Outcome measures

An important strength of the iPlay-study is that all injuries were prospectively registered on a weekly basis. Not only injuries that occurred during sport club activities were registered, but also injuries resulting from participation in other physical activities such as physical education classes and leisure time activities. In other studies, injuries were often recorded through medical channels, which led to a large percentage of severe injuries, while less severe injuries were not registered. In the iPlay-study both severe and less severe injuries were reported and included in our data analyses.

A study limitation is that injuries were measured by means of self-report. Although all teachers were motivated using incentives and reminders to register all injuries during the study, it cannot be excluded that injuries have been missed. Furthermore, sport and physical activity-related injuries were registered during the school year in which the intervention was completed. It would be interesting to examine injury incidence in the subsequent years as well, in order to evaluate the effect of the iPlay-programme over a longer time period.

The data on exposure time were also based on self-report assessed at the start and end of the school year. To register participation in physical activities more optimal, objective weekly registration of exposure time would have been preferable. However, this was not feasible in a study population of more than 2,200 children. Similarly, injury preventive behaviour and behavioural determinants were measured by self-report. We realize that self-reported measures have limitations, such as social desirability and recall bias. The questions concerning

injury preventing behaviour and determinants were not validated but based on standard formulations used in other previous physical activity behaviour studies using the ASE model for behaviour change. The ASE model is based on the theory of planned behaviour[20] and the social learning theory[21]. We adapted the questions to the injury prevention field and pre-tested the questionnaires on comprehensibility, clarity, and practical applicability in 54 children and their parents. Based on the results, questions were adapted, excessive text messages were deleted, and the questionnaire was shortened to increase its comprehensibility.

Neuromotor fitness was assessed with the MOPER fitness test. In more than 2,200 Dutch primary school children, neuromotor fitness, body weight, and body height were measured. These data give a good impression of the neuromotor fitness and anthropometrics of today's children. The validity and reliability of the MOPER fitness test for children aged 10-12 years have been shown to be acceptable[22].

Target population

The iPlay injury prevention programme focussed on all primary school children. However, the results showed that children who are less active had the highest risk for a physical activity-related injury. Therefore, especially less active children will benefit from a physical activity-related injury prevention programme. Nowadays, less active children are stimulated to participate in regular physical activities to improve health and decrease developing overweight. This is expected to increase the number of physical activity-related injuries. Therefore, injury prevention measures should especially focus on less active children.

Compliance

The effectiveness of an intervention programme is largely dependent on the compliance to the programme. Compliance with the intervention was measured by self-report. Results showed that at school level the compliance with the programme was good: 96% of the teachers indicated they distributed the newsletters, 75% displayed the posters and 71% indicated that they performed the exercises frequently. The opinion of the teachers about the iPlay-programme was positive. Compliance at the individual level, i.e. children and parents, was less adequate. Only 28% of the children and 41% of the parents indicated that they had read all the newsletters. The overall rating of the children and parents for the iPlay-programme was 6.6 (on an ascending scale from 1 to 10) (chapter 9). The iPlay-programme was developed in collaboration with the end-users. Mainly teachers were involved in the development of the programme. Children were less involved, whereas parents were not involved. To attain higher compliance of children and parents it would have been preferred to involve children and parents in the development of the intervention programme as well. Although the intervention effect was substantial, the consequences of low compliance by children and parents may have resulted in a lower overall intervention effect.

In summary

Physical activity-related injuries in children are a serious health problem and lead annually to high public health costs. Therefore, injury prevention in children is of great importance for public health. The iPlay-study is the first study that developed a school-based injury prevention programme and evaluated its effectiveness in a cluster randomised controlled trial. During the evaluation study injuries that occurred during the entire scope of physical activity modalities such as sport, leisure time and physical education activities were prospectively reported in a sample of 2,210 primary school children aged 10-12 years. The results showed an overall positive effect of the iPlay-programme on total, sport club, and leisure time injury incidence density as well as injury severity. Unfortunately, the overall effect was not statistically significant due to lack of power. Interestingly, the programme was especially effective in physically less active children. With the current focus on stimulating physically less active children to participate in all kinds of physical activities, injury prevention lessons along side the promotion of physical activities in children is of great importance.

The iPlay-programme significantly improved the behavioural determinants knowledge and attitude. However, this effect on knowledge and attitude was not enough to significantly improve injury-preventing behaviour. In addition, the mediation analysis confirmed our hypothetical model implying that injury-preventing behaviour is determined by intention, attitude, social norm, and self-efficacy. Almost all teachers distributed the various newsletters and posters and taught the exercises frequently. Compliance of children and parents need to be improved.

Practical implications and future research

The effects of the iPlay-programme are promising. However, additional research is needed to optimize the programme. We conclude that our physical activity-related injury prevention programme was beneficial, especially in the less active children. Physically less active children had a higher injury risk. Schools are thus an important setting for injury prevention lessons because both active and less active children can be reached.

To achieve larger effects the iPlay-programme needs to be improved. The iPlay programme was not able to improve social norm, self-efficacy, and intention towards injury preventing behaviours. Apparently other better strategies to improve those variables need to be included in the programme specifically aimed at improving those constructs. In addition, the compliance of children and parents needs improvement. This may be accomplished by including them in the development of an improved programme.

Thus, our study is a successful start in the prevention of physical activity-related injuries in children, but further improvement of the iPlay-programme on the basis of the process evaluation and in collaboration with teachers, children, and parents is necessary.

Recommendations for follow up studies

- Research should focus on the entire scope of physical activity modalities when evaluating physical activity-related injuries in children, as leisure time activities take a large part of the total physical activities in children.
- An injury prevention programme should focus especially on less physically active children because those children have the highest risk for injuries when participating in physical activities.
- Researchers must keep in mind that the cluster-effect in school-based injury prevention studies is high. Therefore, future research should include more schools to increase statistical power.
- When evaluating injury prevention lessons, long-term effects should be examined. This takes considerable logistic effort since primary school children move to different secondary schools.

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