7

General discussion

As a consequence of the low number of children that reach current physical activity guidelines, many initiatives have been developed to stimulate children to become more physically active. A negative side effect of increasing physical activity levels, however, is that subsequent rises in injuries can be expected. These injuries pose an important burden on public health, with upper extremity injuries being most costly[1]. Although children spend over half of their time in unorganized physical activities, most research in children's injuries has focused on the sports setting. The first aim of this thesis was, therefore, to summarize the evidence of injury risk, specifically for upper extremity injuries, of several physical activity behaviours in primary school children. Since children with low levels of physical fitness are at increased injury risk, a broader approach than the sports setting is needed to reach those children[2;3]. The second aim of this thesis was to assess the current knowledge of the impact of community- and school-based interventions on physical activity related injuries. In order to prevent upper extremity injuries in primary school aged children, an educational program to improve fall skills was developed. The third, and last, aim of this thesis was to describe the effectiveness and implementation of this educational program.

Main findings

Physical activity related injury risk in children

In chapter 2, the results of a systematic review on physical activity related injury risk in children is presented. The included studies reported on overall physical activity related injury risk, or on one of four succinct physical activity behaviours; i.e. active commuting, (unorganized) leisure time physical activity, physical education and organized sports. Only studies were included that had reported on the number of injuries, adjusted for exposure to physical activity. The reported incidence rate per 1,000 hours of activity was, as can be expected, lower for leisure time PA compared to sports. The absolute number of injuries was, however, comparable between these two physical activity behaviours.

Chapter 3 focused on upper extremity injuries in a cohort of Danish primary school children. In this cohort, with a follow-up of 2.5 years, parents were asked weekly whether their child had been in pain the previous week. Results showed that: most injuries to the upper extremity had an acute onset (73%); the most often reported injury type was a sprain (55%) and the injury mechanism was a fall in over half of the cases (53%). Cox proportional hazard analysis showed that older children were at increased injury risk compared to their younger peers. A

tendency was found suggesting that girls were at increased injury risk compared to boys.

Community- and school-based injury prevention

Chapter 4 describes the systematic review that was conducted to assess if community-, and school-based physical activity related injury prevention programs can be effective in decreasing physical activity related injury risk in children. Results showed that out of 11 included studies, the majority was school-based (n=9) and focused on increasing the use of safety devices (n=8). On the short term, interventions that distributed safety devices for free were effective in increasing objectively assessed and self-reported safety device use.

The educational program to improve fall skills

The last aim of this thesis was to assess the effectiveness and implementation of an educational program to improve fall skills called 'Vallen is ook een sport'. Therefore, a cluster-randomized trial was conducted. The effectiveness of the educational program is described in chapter 5. Results showed that the number of fall-related injuries per 1,000 hours of physical activity participation in the intervention group was lower when compared to the control group (0.14, 95%CI: 0.09 - 0.18 vs. 0.26, 95%CI: 0.21 - 0.32). However, due to large cluster effects, results failed to reach significance. When an interaction term (intervention group X minutes physical activity) was included into the model, a trend was found suggesting that the educational program to increase fall skills was more effective for the least active children.

Chapter 6 describes a process evaluation of the program using the RE-AIM framework. In this framework, 5 dimensions of research quality are recognised; Reach, Effectiveness, Adoption, Implementation and Maintenance. Reach was almost 100%, since all children participating in physical education lessons were exposed to the educational program. The intervention was effective in increasing self-perceived fall skills and the score on a fall skills test (0.94 points). However, the change in fall-related injury rates did not reach significance. Fourteen percent of invited schools were willing to adopt the educational program. And although the participating teachers were positive about the educational program, 89% failed to implement the exercises as intended. Lastly, 54% of the teachers intended to maintain the educational program in their regular teaching routine. In summary, results are promising, because even though adoption of the

program was lower than expected, the fall skills of children had significantly improved.

Methodological issues

The current thesis comprises of two systematic reviews, injury data of a Danish cohort of primary school aged children and original data collected to assess the effectiveness of an educational program to increase fall skills in 8 to 12 year old children. Some methodological issues related to the methods used were already described in the previous chapters. There are, however, some limitations that should be considered when interpreting the overall results.

Reviews

The reviews described in chapter 2 and 4 used a systematic approach to identify all relevant papers and both included an assessment of the methodological quality. This systematic approach does, however, not completely rule out all bias. A major problem, especially in intervention research, is that positive findings are more likely to be published than negative findings. In systematic reviews with pooled data (i.e. in meta-analysis) a funnel plot can be used to assess potential publication bias[4]. Since pooling was not possible in the reviews described in chapters 2 and 4, this method could, unfortunately, not be applied. Thus publication bias could not completely be ruled out in these chapters.

When performing a review, the strengths of your results are dependent on the quality of studies included. Assessing the risk of bias of studies included is, therefore, one of the obligatory items of the PRISMA-checklist for systematic reviews and meta-analysis[5]. No standard is, however, available on how to assess bias. Thus, the selection of a checklist or items for a checklist is somewhat arbitrary. Another drawback of assessing risk of bias is that review results are usually based on the information as provided in the original publication. Authors may have omitted important details from their report, resulting in an overestimation of the risk of bias. When it is impossible to rate an item based on the study report, the most thorough method would be to approach the authors for additional information. This is, however, time consuming and experience has taught us that all available information is usually reported on. It was therefore decided not to contact authors of the studies included in the two reviews described in this thesis.

Danish cohort

The registration of injuries in the Danish cohort described in chapter 3 was performed alongside the Childhood Health, Activity, and Motor Performance School Study Denmark (CHAMPS Study-DK). The CHAMPS Study-DK itself was part of an initiative for the development of sports schools in the region of Svendborg, Denmark; the so-called 'Svendborg project'[6]. Since researchers were not involved in the development of the intervention, the employed design of the study can be considered as a natural experiment[7]. In general, natural experiments are more susceptible for bias and confounding[7]. This bias was minimal for the questions posed in chapter 3, as it was not of our interest to evaluate differences between school types. The main concern was that schools were not representative. Parents were, therefore, not informed about the Svendborg project until after the start of the school year to minimize their influence on school choice.

Although participation of all schools started at the beginning of the 2008-2009 school year, the registration of injuries was gradually introduced at the schools over a period of 8 months. Reason for this was that the relatively novel method of data collection (SMS-track) in combination with the clinical examination of injuries needed a phasing-in-process. In the first weeks of the injury registration, an overload of injuries was expected, since the parents would then report all prevalent injuries. The data were checked for over reporting in the first weeks of injury data collection, but at least for the upper extremity injuries, this phenomenon was not observed.

The fact that objective assessment of overall physical activity was only performed halfway during the data collection period could, of course, be considered a methodological issue. For the data described in chapter 3 this is actually a strength, because physical activity data collected one year after the start of the study is likely to be more representative. We are aware, though, that it is not completely correct to include these data into the Cox regression analysis.

Dutch randomized controlled trial

The evaluation of the Dutch educational program to improve fall skills in children was designed as a cluster-randomized controlled trial, with randomization taking place at the school level. Although randomized controlled trials are generally considered to be of the highest methodological quality, there are some limitations that should be considered.

Before the start of the study, interest of Dutch primary schools for fall-related injury prevention was tested by offering a limited number of fall clinics. These clinics received national press coverage, and interest of schools exceeded expectations: 250 (out of a little under 7,000) primary schools could not participate in the fall clinics and were placed on a waiting list. Because recruiting Dutch primary schools for research is extremely difficult[8;9], it was decided not to approach a random selection of schools, but to contact the schools on the waiting list if they were interested in participating in the study. Thirty-six (14%) of these 250 waiting list schools were willing to participate. Since schools were selected from a pool of schools already interested in improving fall skills, generalizability to all schools in the Netherlands may be hampered.

Before the start of the study, an a-priory power calculation was performed. Using a power of 80%, an α of 5% (two-sided) and an assumed dropout rate of 10%. Since no data were available on cluster effects between schools, the sample size was arbitrarily increased by another 30%. This resulted in a final required sample size of 3,264. The statistical analysis, however, revealed that the inter cluster correlation was unexpectedly high: 0.5. This means that we might have had too little power to reveal any statistically differences between control and intervention groups.

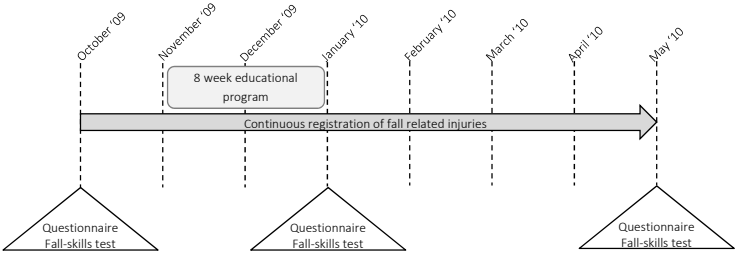
Within the randomized controlled trial, three types of data were collected (Figure 7.1), namely; responses to self-reports by the use of questionnaires, a fall-skill test and the continuous registration of sustained injuries. Each of these data collection methods has their own limitations.

The use of self-reports is known to have drawbacks, such as social desirable answers and recall bias. It was, however, not possible to obtain objective physical activity data or to perform a fall-skills test in all 3,317 children. To minimize recall bias, children were asked about sports and outdoor play in the previous week in a structured manner, such as to minimize recall bias. Although questionnaire questions were used in previous research, no information is available on the validity of responses in 8 to 12 year old children. Especially of concern are the responses of the younger children, since their reading skills

might not have been sufficient. It has, however, been reported that children over 8 years are capable of providing reliable reports on wellbeing[10].

The fall-skills test was performed only in a subsample of the study population. The sample consisted of children of all grades, and each class was selected from a different school. This selection was based on the proximity of the school to VU University Medical Center, and not a random sample. Also, validity of the fall-skills test is unknown.

Figure 7.1: Distribution of the educational program and data collection moments throughout the school year.



Recall bias is of special concern in the continuous registration of injuries in two ways. Teachers have to remember to ask the children each week if any of them had sustained an injury. The children, on the other hand, have to remember that they had been injured the previous week. Recall bias could have been reduced, if parents would have been asked to report injuries instead of teachers, by for example an SMS-tracking system. Unfortunately, there was no funding for this type of data collection.

The dropout rate after baseline measurement was higher than anticipated in the power calculation (15% instead of 10%). The 10% dropout rate was based on previous research in a comparable, but not entirely identical, setting (that is, the iPlay-study[11]). Two main differences between the current study and the iPlay-study were that in the iPlay-study, researchers were present at the schools to collect the data, while in the current study researchers were dependent on the teachers to return the questionnaires by regular mail. Also, in the current study, three measurement points were used, compared to two measurement points in

the iPlay-study. According to the power calculation, 2,938 children were needed. The current study was, a little underpowered, with 2,836 children supplying complete data.

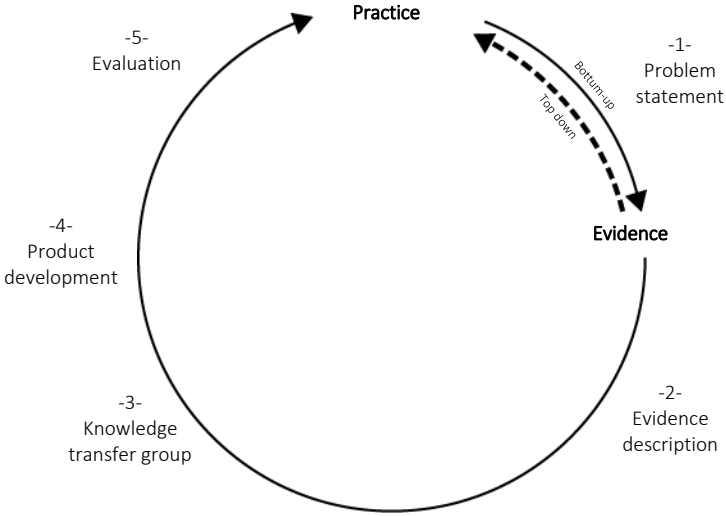
Implementation

As described in chapter 6, the educational program was not effective in reducing the odds of sustaining a fall-related injury in children. Evaluation using the RE-AIM framework revealed that especially adoption of the program and compliance to the program by teachers was rather low. A more detailed insight in the development of the educational program could show potential pitfalls and possible clues for improvement of the program.

The development and evaluation of the educational program to improve fall skills was a rather unique project because of the bottom-up development of the intervention. The Dutch Consumer Safety Institute registered an increase in forearm fractures in Dutch children treated at emergency departments. As a consequence, the educational program to improve fall skills was developed by the Dutch Consumer Safety Institute in collaboration with a Dutch judoka. After the intervention was developed, researchers were approached to assess the effectiveness and implementation of the educational program. This bottom-up approach is unique: sports and physical activity-related injury prevention usually follows a top-down path, using the widely adopted sequence of prevention[12;13].

It was recently recognized that combining the research driven top-down approach with the practice driven bottom-up approach provides the best option to tackle an injury problem. These two approaches were, therefore, combined in the five steps of the knowledge transfer scheme (KTS[13], Figure 7.2). Key in the KTS is that a focus is put on the end-users and their characteristics, strengths and challenges. Furthermore, all stakeholders should be involved in the development of the intervention. Although a pilot project was undertaken to explore feasibility of the exercises and potential interest of teachers, this might have been too little involvement of the end users in the development of the educational program to ensure optimal implementation.

Figure 7.2: The five step Knowledge Transfer Scheme.



Source: Verhagen et al., 2013[13].

Another drawback in the development of the educational program, which is partly linked to the bottom-up development, is that no theoretical framework was used. For sports injury research, Finch first recognized the importance of a theoretical framework for the Translating Research into Injury Prevention Practice (TRIPP) model[14]. A theoretical framework provides a tool to move beyond intuition about what might work, to the design and evaluation of interventions requiring adoption and maintenance of safety behaviours in the real world[15;16]. The lack of a theoretical framework is unfortunately fairly common in sports injury prevention research. In a recent review, only 11% out of 100 sports injury prevention studies were reported to apply any formal theoretical consideration, most of which were theories in relation to the individual-level[16]. Since injury prevention, especially the educational program evaluated here, includes not only the individual level of the child, but more importantly the adherence and maintenance of the teachers, the theoretical model should also include higher-level theories. The use of higher-level theoretical frameworks in current injury prevention studies is rare[16].

The future of injury prevention in children

With the current focus on a physically active lifestyle, a future increase in the number of injuries is to be expected. Not only because time at risk will increase, but mainly because these physical activity programs specifically targets insufficiently active children. These children are more likely to have a low level of physical fitness, low muscle strength and low fundamental movement skills, resulting in an increased physical activity related injury risk. A promising finding in previous research is that, although children with low levels of physical activity are at increased injury risk, they are also the ones who benefit most from injury prevention initiatives[8].

Research on training of motor skills in young children is scarce, but a recent small-scale study showed that 15 minutes of neuromuscular training, twice a week for eight consecutive weeks was effective in increasing motor skills in 7-year-old children[17]. If this has resulted in a decreased injury risk has yet to be determined. These findings, however, pose important possibilities for future research. In adults, neuromuscular training has been linked to significant reduction of lower extremity injuries[18]. As such, one could argue that a comparable effect may exist in children too.

On the other hand, improving motor skills in children could potentially increase their enthusiasm for being physically active. It is very likely that inactivity and low

motor skills are linked, but how they influence each other is still unknown. It could be that children with low motor skills feel insecure, which makes them less likely to participate in physical activity. Conversely, it is very unlikely that motor skills of an inactive child will spontaneously improve; it might even worsen. Breaking this vicious circle could open up possibilities for both increasing activity levels and decreasing injury risk in children with low levels of physical activity.

What is maybe most important, especially in young children, is that they learn to enjoy being physically active. For this young target group, injury prevention should first of all be fun. Preventive exercises can be introduced in a playful way to young children. This might not result in immediate effects, but will make children familiar with the exercises from which they can benefit on at older age. Such an attempt is currently under preparation by the International Football Federation (FIFA). Exercises of the FIFA 11+ warm-up injury prevention program, which was reported to be effective in decreasing the number of injuries by 30-50% in adults[19], is now being adjusted for use in children under 12 years of age. This is, of course, an example of injury prevention in a sports setting. But lessons learned within this project can, at a later stage, be translated into a general program for all children.

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