ARTICLE

# Effectiveness of a School-Based Physical Activity Injury Prevention Program

## *A Cluster Randomized Controlled Trial*

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**Objective:** To study the effects of a school-based injury prevention program on physical activity injury incidence and severity.

**Design:** Cluster randomized controlled trial performed from January 1, 2006, through July 31, 2007.

**Setting:** Forty Dutch primary schools.

**Participants:** A total of 2210 children (aged 10-12 years).

**Intervention:** Schools were randomized to receive either the regular curriculum or an intervention program that targeted physical activity injuries.

**Outcome Measures:** Incidence and severity of physical activity injuries per 1000 hours of physical activity participation.

**Results:** A total of 100 injuries in the intervention group and 104 injuries in the control group were registered. Nonresponse at baseline or follow-up was minimal (8.7%). The Cox regression analyses adjusted for clustering showed a small nonsignificant intervention effect on total (HR, 0.81; 95% confidence interval [CI], 0.41-1.59), sports club (0.69; 0.28-1.68), and leisure time injuries (0.75; 0.36-1.55). However, physical activity appeared to be an effect modifier. In those who were less physically active, the intervention had a larger effect. The intervention reduced the total and leisure time injury incidence (HR, 0.47; 95% CI, 0.21-1.06; and 0.43; 0.16-1.14; respectively). Sports club injury incidence was significantly reduced (HR, 0.23; 95% CI, 0.07-0.75).

**Conclusion:** We found a substantial and relevant reduction in physical activity injuries, especially in children in the low active group, because of the intervention. This school-based injury prevention program is promising, but future large-scale research is needed.

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THE HEALTH BENEFITS OF regular physical activity (PA) in children are widely known and include a decrease in cardiovascular risk factors, enhanced bone health, and reduction of the risk of obesity and type 2 diabetes mellitus.[1-3] Participation in PA, however, also increases the risk of adverse effects, such as injuries, and with the current focus on a physically active lifestyle, increasing numbers of PA injuries can be expected.[4] Although most PA injuries in children are not life-threatening, they may coincide with direct pain, short-term disability, school absence, and long-term consequences such as osteoporosis in later life, all of which lead to high direct and indirect costs.[5-8] Moreover, children may lose their enthusiasm for participating in PA because of negative associations with injuries.[9] Given the consequences and costs of PA injuries, prevention of such injuries in children is an important public health issue.

Although the magnitude of pediatric PA-related injuries has been shown in several studies,[10-14] most preventive research within the sports injury field has been performed with adults. Moreover, a great part of the PA of a child consists of leisure time activities other than sports, and the risks associated with such a wide spectrum of PA have hardly been investigated. Previously performed prevention studies[15] concentrated on specific sports and/or specific injuries. To the best of our knowledge, intervention studies with regard to the effectiveness of school-based PA injury prevention programs in children are lacking. The objective of this study is to evaluate the effects of a school-based PA injury prevention program on PA injury incidence density (IID) and injury severity.

## METHODS

### DESIGN AND PARTICIPANTS

The Injury Prevention Lessons Affecting Youth (iPlay) study was designed as a cluster randomized controlled trial. In January 2006, a total of 520 of 7000 Dutch primary schools located in urban and suburban areas were randomly invited to participate in the study. Inclusion criteria for the schools were (1) being a regular primary school, (2) giving physical education (PE) classes twice a week, and (3) being willing to appoint a contact person for the duration of the study. All children in grades 5 and 6 (10-12 years of age) from the participating schools were eligible to participate in the study.

Parents of the participating children received a passive informed consent form that explained the nature and procedures of the study. If parents and/or their child(ren) did not want to participate, they could withdraw. The Medical Ethics Committee of VU University Medical Center approved the study design, protocols, and informed consent procedures.

### THE iPLAY INTERVENTION

The iPlay intervention program was developed according to the intervention mapping protocol. This protocol describes a structured approach for the design of theory-based and evidence-based health programs.[16] The 8-month intervention program focused on both children and parents. Each month children received a newsletter aimed at improving knowledge, attitude, and self-efficacy toward the prevention of PA injuries. Each month parents also received a newsletter, aimed at improving knowledge about injury prevention, that suggested strategies to reduce injury risk for their child(ren). In addition to newsletters, posters that addressed the main topics with regard to injury prevention were continuously displayed in the classroom. The iPlay Web site contained all sorts of interactive information for children, parents, and PE teachers.

In addition, 5-minute exercises were given at the beginning and end of each PE class. These exercises were aimed at improving strength, speed, flexibility, and overall coordination. During the first PE class, strength and coordination exercises were performed. During the next PE class, speed and flexibility exercises were performed. Teachers were able to choose from 5 different speed, strength, coordination, and flexibility exercises. A more detailed description of the exercises is given in an article by Collard et al.[17]

A teachers' manual contained all the information about the iPlay program, including schedule, explanation of the exercises, and newsletter topics. The intervention focused in particular on prevention of lower-extremity PA injuries, because those are the most common.[18]

### OUTCOME MEASURES AND DEMOGRAPHICS

The objective of this study was to evaluate the effect of the iPlay intervention on PA IID (number of injuries per 1000 hours of sports participation) and injury severity. At the start (September 3, 2006) and end (June 30, 2007) of the school year, all children completed a questionnaire in the classroom. The baseline questionnaire collected information on demographic variables, such as age, sex, ethnicity, and socioeconomic status. Children were classified as being of western or nonwestern ethnicity on the basis of the definition used by the Dutch Central Bureau for Statistics.[19] Children with at least 1 parent born in Turkey, Africa, Latin America, or Asia were classified as nonwestern immigrants. Children with at least 1 parent born in Europe, North America, Oceania, Indonesia, or Japan were classified as western immigrants. Socioeconomic status was assessed using the highest level of maternal education, which was self-reported via a questionnaire for parents and ranged from 1 (no qualification) to 8 (master's degree).

### ANTHROPOMETRICS

Body height was measured in meters with a portable stadiometer (Seca 214, Leicester Height Measure; Seca GmbH & Co, Hamburg, Germany). Body weight was measured in kilograms with a digital scale (Seca 770; Seca GmbH & Co. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared, and we used the age-specific and sex-specific cutoff points to determine weight status.[20]

### EXPOSURE TIME

The questionnaire also included questions about frequency and duration of sports club and leisure time activities during the last week.[21] If the last week was not a regular week (because of vacation or sickness, for example), children were asked to complete the questions in regard to a regular week. Sports activities were defined as structured activities or sports clubs. Leisure time PA was defined as unstructured PA during leisure time.

Exposure to PE classes (ie, twice a week for 45 minutes) was multiplied by the intervention duration in weeks, taking the regular school holidays into account. Individual exposure to sports activities and leisure time PA was derived from data from the baseline and follow-up questionnaires. From these data the mean weekly exposure was calculated, which was multiplied by the number of intervention weeks. Finally, a correction factor of 0.8 was used to account for seasonal effects on PA participation throughout the school year. Although chosen arbitrarily, this correction factor is in line with decreased PA during wintertime, as found in previous studies.[22,23] Weekly leisure time PA exposure was missing for 35 children. There were no missing data with regard to exposure to sports participation.

### PA INJURIES

Every week PE teachers asked the children whether they were injured as a result of PA in the past week. In case of a PA injury, children completed an injury registration form. This form collected information on injury type, location, direct cause, and activity performed at the time of the injury (ie, PE class, sports, or leisure time PA).

We adapted the injury definition as described by van Mechelen et al.[24] A PA injury is any injury as a result of participation in PE class, sports activities, or leisure time PA with 1 or more of the following consequences: the child (1) has to stop the PA and/or (2) cannot (fully) participate in the next planned PA and/or (3) cannot go to school the next day and/or (4) needs medical attention (eg, from providers ranging from first aid personnel to general physicians or physiotherapists). Reported PA injuries that did not meet this injury definition were excluded from the analyses. The severity of PA injuries was categorized on sporting time lost (no sporting time lost vs 1 or more days of sporting time lost). Using a cost diary, parents of the injured child reported sporting time lost.

### RANDOMIZATION

Before baseline measurements and after all schools were enrolled, a randomization was performed using a computerized random number generator, with stratification for geographic

location of the school (urban or suburban) and professional status of the PE teacher (certified or uncertified). Randomization took place at the school level. The researchers informed the schools of the allocation before the start of the school year. The intervention group received the iPlay program during 1 school year, whereas the control group followed the regular curriculum. The control group received 2 information sheets with information about the iPlay study and the measurements but no information about injury prevention. Participants and researchers were not masked to group allocation.

### STATISTICAL ANALYSIS

The IID was calculated for total PA participation and for 3 different modalities of PA (ie, PE classes, leisure time, and sports activities). The IID is reported as the number of new injuries per 1000 hours of PA participation, using exposure time of each individual until the first injury. The number of injuries divided by the total time at risk is the preferred measure of incidence because it can accommodate variations in the exposure time of individuals.[25,26] If a child had multiple injuries, only the first injury was considered in the analysis.

Because the unit of allocation was schools, we performed a multilevel Cox proportional hazard regression analysis, using Stata statistical software, version 10 (StataCorp, Chicago, Illinois), to estimate the hazard ratios (HRs) and 95% confidence intervals (CIs). Schools were used as cluster levels.[27]

To analyze the difference in injury severity (injured children with sporting time lost) between the intervention and control groups, a multilevel logistic regression was performed using Stata statistical software, version 10. All analyses were adjusted for ethnicity, socioeconomic status, and BMI. We checked for possible effect modification by sex, grade of urbanization, ethnicity, BMI, class, and PA exposure time.

## RESULTS

### PARTICIPANTS

A total of 2210 children (aged 10-12 years) from 40 primary schools throughout the Netherlands participated in the study. All children, except for 2 in the control group who refused to participate, completed the entire follow-up period.

**Figure 1** outlines the complete flow of participants from recruitment through the last follow-up contact (January 1, 2006, to July 31, 2007). Reasons for not completing the baseline or follow-up exposure were mostly school absence because of illness or having a medical appointment (eg, physician, dentist, or orthodontist). Data from 8 children were excluded from analysis because those children completed the questionnaire incorrectly. Eventually, data from 1015 children in the intervention group and 996 children in the control group were analyzed. All analyses were performed according to the intention-to-treat analysis. There were no deviations from the protocol as planned and no reported adverse effects.

**Table 1** presents baseline characteristics of the study population. The mean (SD) age of the children was 10.7 (0.8) years. At baseline, children in the intervention group reported significantly more PA (mean [SD], 559 [231] minutes per week) than children in the control group (mean [SD], 511 [232] minutes per week). Children in the intervention group reported an especially large number of activities during leisure time. In addition, children in the control group were more often from a nonwestern ethnic background and tended to have a higher BMI.

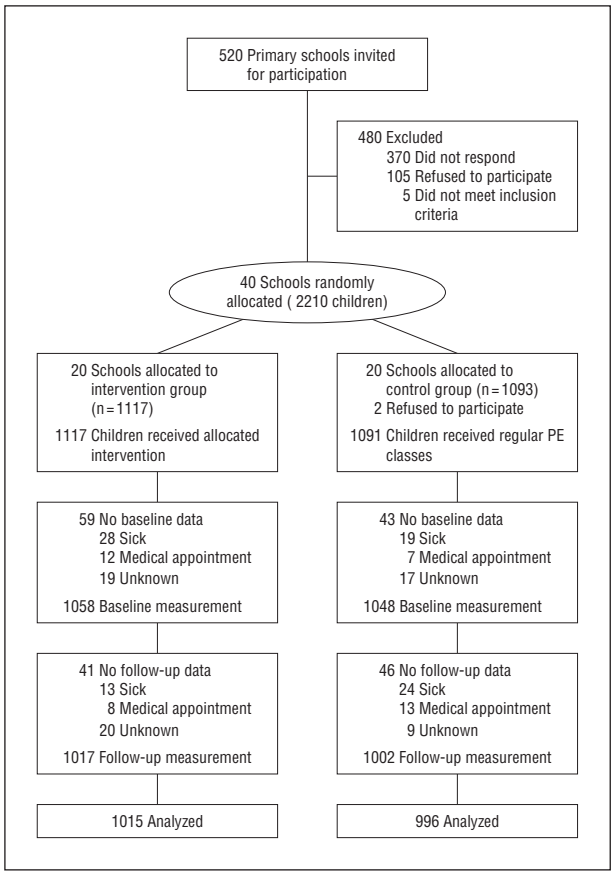


**Figure 1.** Flow of participants from recruitment to the last follow-up contact. PE indicates physical education.

### EFFECTS ON PA INJURY INCIDENCE

The total numbers of PA injuries registered during 1 school year in the intervention and control groups were 100 and 104, respectively. **Table 2** summarizes the number of PA injuries and the IID in the intervention and control groups for total PA injuries and the different modalities of PA and the Cox proportional hazard regression analysis with adjustment for clustering. The IID for total PA participation was 0.38 (95% CI, 0.31-0.46) in the intervention group, compared with 0.48 (95% CI, 0.38-0.57) in the control group.

The Cox proportional hazard regression analyses showed a nonsignificant intervention effect on total injuries after adjustment for clustering (HR, 0.81; 95% CI, 0.41-1.59). When we considered the different modalities of PA, small nonsignificant effects on injuries during sport and leisure time activities were found (HR, 0.69; 95% CI, 0.28-1.68; and 0.75; 0.36-1.55; respectively).

After adjustment for clustering, we found not only wider 95% CIs but also a change in point estimates. Thus, the cluster effect in our study was much higher than expected. Looking at the data, we observed a large difference in IID between schools with different PA exposure

**Table 1. Baseline Characteristics in Children in Intervention and Control Groups**

| Characteristics | Intervention Group (n=1015) | Control Group (n=996) |
|---|---|---|
| Age, mean (SD), y | 10.7 (0.8) | 10.7 (0.8) |
| Sex, No. (%) | | |
| Male | 495 (48.8) | 493 (49.5) |
| Female | 520 (51.2) | 503 (50.5) |
| BMI, mean (SD) | 17.7 (2.7) | 18.1 (3.1) |
| BMI class, No. (%)[a] | | |
| Healthy weight | 819 (80.7) | 779 (78.2) |
| Overweight and obese | 142 (14.0) | 170 (17.1) |
| Unknown | 54 (5.3) | 47 (4.7) |
| Ethnicity, No. (%) | | |
| Western | 849 (83.6) | 727 (72.9) |
| Nonwestern | 121 (11.9) | 229 (22.9) |
| Unknown | 45 (4.4) | 40 (4.0) |
| SES, No. (%) | | |
| Low | 492 (48.5) | 386 (38.8) |
| High | 331 (32.6) | 364 (36.5) |
| Unknown | 192 (18.9) | 246 (24.7) |
| Physical activity, mean (SD), min/wk | | |
| Physical education class | 90 | 90 |
| Organized sports | 145 (131) | 131 (132) |
| Leisure time | 320 (168) | 287 (173) |
| All | 559 (231) | 511 (232) |

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); SES, socioeconomic status.
[a] Using cutoff values described by Cole et al.[20]

times. Therefore, we performed subgroup analyses for children in the high active and low active groups.

### HIGH ACTIVE VS LOW ACTIVE GROUP

Children who reported less than 414 minutes per week of PA (median) were categorized as low active. Children who reported 414 or more minutes per week of PA were categorized as high active. **Table 3** summarizes the IID for the intervention and control groups and the effect of the iPlay program on IID for the high active and low active groups. In the low active group, effects of the iPlay program were much larger, with a 50% reduction in total injuries (HR,0.47; 95% CI, 0.21-1.06) and a more than 50% reduction for sports injuries (HR,0.23; 95% CI, 0.07-0.75) and leisure time injuries (HR,0.43; 95% CI, 0.16-1.14).

### EFFECTS ON SEVERITY OF THE INJURIES

**Figure 2** shows the percentages of injured children with sporting time lost in the intervention and control groups for total, sports club, leisure time, and PE class injuries. Children in the intervention group reported fewer severe injuries than those in the control group. The multilevel logistic regression analyses showed that there was no significant difference between the intervention and control groups in the percentage of children with sporting time lost.

## COMMENT

### EFFECTS ON PA INJURY INCIDENCE AND SEVERITY

The iPlay study was the first, to our knowledge, to evaluate a school-based PA injury prevention program. In the literature there are some studies that evaluate school-based intervention programs, but most of them focus on injury prevention in general (eg, bike and pedestrian safety, falls, poisoning, and fire burns)[28-30] or on sport-specific injury prevention (eg, high-school basketball).[31]

Our school-based injury prevention program showed a reduction in IID and injury severity in primary school children (aged 10-12 years). The reduction was not significant in the total group because of the unexpectedly large cluster effects.

In the low active group, the intervention effect was much larger. However, because of the smaller sample size, this effect was not significant. A significant effect was found for sports club IID. Children in the intervention group had approximately 3 times less risk for a sports club injury than children in the control group.

### COMPARISON WITH LITERATURE

To our knowledge, only 1 study focused especially on school-based prevention of PA injuries in children.[32] This controlled experimental study evaluated an injury prevention program designed for children aged 12 to 20 years. It showed a minor reduction in injury incidence rates.

### STRENGTHS AND LIMITATIONS OF THE STUDY

One strength of the present iPlay study is the large sample size: 2210 children from 40 different primary schools. The intervention program was developed according to the intervention mapping protocol tailored to the needs and possibilities of the target population. This is an important element for a successful community-based program.[33] Moreover, the intervention program appeared easily implementable, was time efficient, and fit the regular school curriculum. The study population was a good representation of the Dutch population as a whole.

Last but not least, an important strength of this study is that all PA injuries that resulted from sports activities, PE class, and leisure time PA were registered in a school setting. Often, PA injuries are only recorded through medical channels, which will result in a large percentage of serious injuries, whereas less serious injuries will be underreported. Thus, only part of the total PA injury problem is revealed: the "tip-of-the-iceberg" phenomenon.[34] In this study both serious and less serious injuries that resulted from participation in structured and unstructured PA were reported.

A drawback of the study is that PA injuries were registered by means of self-report. Self-report of PA injuries leaves open the possibility that some injuries were missed. To report PA injuries as adequately as possible, all PE teachers were informed of the definition of a PA injury and they were contacted frequently by telephone or e-mail in an attempt to minimize underreporting.

**Table 2. Effect of the iPlay Intervention on PA Injury Incidences**

| | No. of Injuries | | Injury Rate (Injuries per 1000 Hours of Exposure) | | HR (95% CI)[a] (Adjusted for Clustering) |
|---|---|---|---|---|---|
| | Control Group | Intervention Group | Control Group | Intervention Group | |
| Total PA injuries | 104 | 100 | 0.48 (0.38-0.57) | 0.38 (0.31-0.46) | 0.81 (0.41-1.59) |
| Sports club injuries | 40 | 44 | 0.66 (0.41-0.76) | 0.58 (0.41-0.76) | 0.69 (0.28-1.68) |
| Leisure time injuries | 48 | 40 | 0.39 (0.28-0.50) | 0.26 (0.18-0.34) | 0.75 (0.36-1.55) |
| PE class injuries | 22 | 24 | 0.50 (0.31-0.71) | 0.51 (0.41-0.71) | 1.11 (0.46-2.64) |

Abbreviations: CI, confidence interval; HR, hazard ratio; iPlay, Injury Prevention Lessons Affecting Youth; PA, physical activity; PE, physical education.
[a] Multilevel Cox regression adjusted for ethnicity, socioeconomic status, and body mass index.

**Table 3. Effect of the iPlay Intervention on PA Injury Incidence Density for Children in High Active and Low Active Groups**

| | High Active Group | | | Low Active Group | | |
|---|---|---|---|---|---|---|
| | Injury Rate (Injuries per 1000 Hours of Exposure) | | HR (95% CI)[a] (Adjusted for Clustering) | Injury Rate (Injuries per 1000 Hours of Exposure) | | HR (95% CI)[a] (Adjusted for Clustering) |
| | Control Group | Intervention Group | | Control Group | Intervention Group | |
| Total PA injuries | 0.43 (0.31-0.54) | 0.39 (0.29-0.48) | 1.02 (0.49-2.10) | 0.53 (0.38-0.68) | 0.37 (0.24-0.49) | 0.47 (0.21-1.06) |
| Sports club injuries | 0.53 (0.30-0.76) | 0.59 (0.38-0.80) | 1.11 (0.38-3.23) | 0.91 (0.51-1.31) | 0.61 (0.28-0.94) | 0.23 (0.07-0.75)[b] |
| Leisure time injuries | 0.33 (0.20-0.46) | 0.26 (0.16-0.36) | 0.85 (0.39-1.87) | 0.45 (0.26-0.64) | 0.24 (0.10-0.38) | 0.43 (0.16-1.14) |
| PE class injuries | 0.65 (0.28-1.02) | 0.49 (0.21-0.77) | 0.90 (0.33-2.44) | 0.41 (0.15-0.66) | 0.55 (0.24-0.86) | 1.22 (0.30-4.92) |

Abbreviations: CI, confidence interval; HR, hazard ratio; iPlay, Injury Prevention Lessons Affecting Youth; PA, physical activity; PE, physical education.
[a] Multilevel Cox regression adjusted for ethnicity, socioeconomic status, and body mass index.
[b] Significant difference between intervention and control groups ($P < .05$).

Exposure time was also self-reported because this was the only feasible means of collecting exposure data in such a large sample. In this study, exposure time was assessed at the start and end of the school year. Weekly registration of exposure time would have been preferable. However, this was not feasible. This method of self-reported exposure might have resulted in a slight overestimation of actual exposure to leisure time PA and sports.

Another limitation of the study is that the participants and research assistants were not masked. Masking of participants and research assistants is important to prevent bias, but in a trial like this one, masking is difficult to attain.

### GENERALIZABILITY

Only 8.7% of all 520 invited schools agreed to participate. The nonresponse rate of primary schools in this study was 71.2%. Of total primary schools, 20.2% of the primary schools indicated that they did not want to participate, mostly because of lack of time. Schools that did not want to participate were not different than participating schools with regard to geographic location (urban vs rural). Comparison of the participating schools and nonparticipating schools with regard to other variables than geographic location is not possible because information with regard to those variables is lacking.

## CONCLUSIONS

Our findings are encouraging for the prevention of PA injuries in children. Although our findings were not statistically significant, we found a substantial and relevant reduction in PA injuries, especially in the children from the low active group, because of the iPlay intervention. Therefore, we believe that this school-based injury prevention program is promising, but future research is needed.

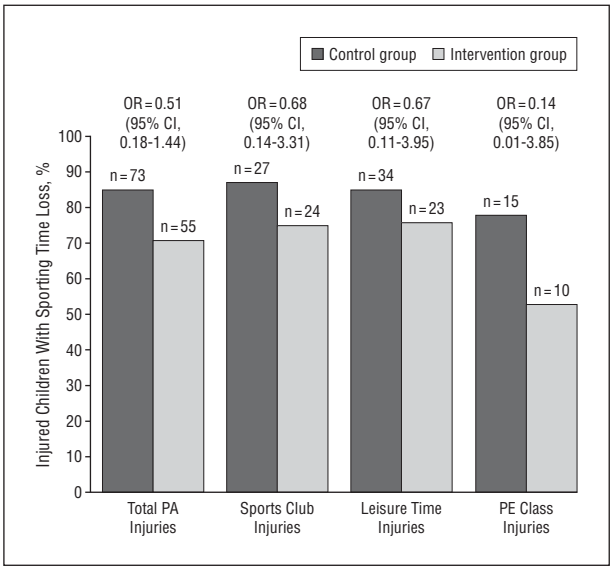


**Figure 2.** Percentages of injured children with sporting time lost in intervention and control group for total, sports club, leisure time, and physical education (PE) class injuries and the odds ratios (ORs) with 95% confidence intervals (CIs). The OR does not approximate relative risk.

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