

Physical inactivity is a risk factor for physical activity-related injuries in children

Frank Bloemers,¹ Dorine Collard,² Mai Chin A Paw,³ Willem Van Mechelen,³ Jos Twisk,⁴ Evert Verhagen³

¹Department of Traumasurgery, VU University Medical Center, Amsterdam, The Netherlands

²Centre of Research on Sports in Society, W.J.H. Mulier Institute, Utrecht, The Netherlands

³Department of Public and Occupational Health, EMGO Institute for Health and Care Research, VU University Medical Center, Amsterdam, The Netherlands

⁴Department of Health Sciences, Section Methodology and Applied Biostatistics, VU University Medical Center, Amsterdam, The Netherlands

Correspondence to

Evert Verhagen, Department of Public and Occupational Health, EMGO Institute for Health and Care Research, VU University Medical Center, Van der Boechehorststraat 7, 1081 BT, Amsterdam, The Netherlands; e.verhagen@vumc.nl

Received 1 September 2011

Accepted 12 November 2011

Published Online First

14 December 2011

ABSTRACT

Objectives To describe the risk factors associated with injuries resulting from physical education (PE), leisure time physical activity (leisure time PA) and sports in 9–12-year-old children.

Design Prospective cohort study.

Setting Primary schools.

Participants Nine hundred and ninety-five children aged 9–12 years.

Main outcome measures Injuries occurring during either PE class, leisure time PA or sports, and caused the child to at least stop the current activity were recorded prospectively. Individual weekly exposure was estimated from baseline and follow-up questionnaires. Potential risk factors were gender, age, socioeconomic status, ethnicity, habitual level of PA, body mass index and a motor fitness. A multivariate Cox proportional hazard regression model was developed, accounting for clustering within schools.

Results Gender, age and level of PA were independent significant risk factors for injury. Different modalities of PA had different injury risk factors. Most importantly, the low levels of habitual PA significantly increased injury risk.

Conclusions The children at highest injury risk are the target audience of the contemporary PA promotion efforts. PA promotion should also focus on injury prevention.

INTRODUCTION

The beneficial effects of regular physical activity (PA) on physical, cognitive and mental health in school-aged children have been well documented.^{1–4} However, PA and participation in sports have an inherent risk for injury.^{5–9} Compared with adults, the risk for injury resulting from participation in sports and free play in children is low. Nevertheless, these injuries pose a substantial individual socioeconomic burden.^{7 10 11} More importantly, children may lose their enthusiasm for healthy activities and sports through negative associations with injury.¹²

With the contemporary focus on a physically active lifestyle, an increasing number of PA and sports-related injuries can be expected. Consequently, successful injury prevention in school-aged children has great potential public health gain.¹³ In order to inform such preventive measures, we need a descriptive injury epidemiology describing the burden of injuries and aetiology of injuries.¹⁴ However, recent reviews on the burden and aetiology of sports injuries in children revealed that epidemiological data on this topic

are scarce.^{15 16} Moreover, recent data highlight that next to injury prevention during organised sports activities, a preventive focus on unorganised free play activities in younger age groups is important as well.⁹ This holds especially true for younger children within the age range of 10–12 years. These children are growing, learning and developing their motor skills. During this process, the younger child ‘evolves’ from a participant in joyful PA to a participant in sports.¹³

Although descriptive injury data for this specific age group across various modalities of PA are scant, aetiological knowledge that provides a basis for preventive efforts is completely lacking. Therefore, the purpose of this prospective cohort study was to describe the risk factors associated with injuries resulting from physical education (PE), leisure time PA and sports in 9–12-year-old children.

METHODS

Population

This study was part of the iPlay study, an injury prevention study carried out in the two highest grades of Dutch primary schools.¹⁷ A total of 40 regular primary schools (consisting of 2208 children of 9–12 years) were randomised to an intervention group or a control group and were followed prospectively for 1 school year. All 20 schools assigned to the control group formed the cohort described in this study, resulting in a cohort of 1091 children of 9–12 years. The study was approved by the Medical Ethics Committee of the VU University Medical Center, Amsterdam, The Netherlands. Informed consent was given by each child’s parent or guardian by means of a passive informed consent. All children in participating schools partook in this study, and no objections for participation were received from parents or guardians.

Risk factor definitions

At the start (September 2006) and end (June 2007) of the school year, all children completed a questionnaire in the classroom under the supervision of the researchers.¹⁷ The baseline questionnaire collected information on demographic variables, including age, gender, ethnicity and socioeconomic status (SES).

Children were classified as being of western or non-western ethnicity on the basis of the definition used by the Dutch Central Bureau for Statistics.¹⁸ Children with at least one parent born

Original article

in Turkey, Africa, Latin America or Asia were classified as non-western immigrants. Children with at least one parent born in Europe, North America, Oceania, Indonesia or Japan were classified as western immigrants.

SES was assessed using the highest level of maternal education, and ranged from one (no qualification) to eight (master's degree), and for the analyses recoded into low, medium or high SES based upon the definition used by the Dutch Central Bureau for Statistics.¹⁸

Individual weekly exposure to sports and leisure time PA was derived from the baseline and follow-up questionnaires. Both questionnaires contained standardised questions on the weekly frequency and duration of sports and leisure time PA, from which weekly exposure was estimated. Individual weekly exposures were categorised into quartiles, where the lowest quartile represented the least active 25% of the population.

During a single PE, class motor fitness was assessed by the motor performance (MOPER) fitness test.¹⁹ Supervised by a researcher, groups of three to four children performed seven test items of the MOPER fitness test (bent arm hang test, 10.5-m run test, plate tapping test, leg lift test, sit and reach test, arm pull test and standing high jump test). Children were encouraged to perform all test elements to the best of their ability. For practical reasons, the 6-min endurance run was excluded. All test items were performed barefoot to rule out the effect of footwear on the test results. Scores of the individual test items were categorised in age- and gender-specific tertiles, from which an overall MOPER score was derived (low, medium or high).

As part of the MOPER fitness, test body height and body weight were measured of each child. Body height was measured in metres, with a portable stadiometer (Seca 214, Leicester Height Measure; Seca GmbH & Co, Hamburg, Germany) with the subject standing straight against a wall, with the heels together and looking straight ahead. Body weight was measured in kilograms, with a digital scale (Seca 770; Seca GmbH & Co, Hamburg, Germany). Body mass index (BMI) was calculated by the weight in kilograms divided by height in square metres (kg/m^2), and for the purpose of the analyses recoded into gender- and age-specific quartiles.

Exposure time

Exposure to PE classes was equal for all children, that is twice a week for 45 min. The weekly individual exposure of 90 min was multiplied by the number of weeks between baseline and follow-up, taking the regular school holidays into account.

Mean weekly sports and leisure time PA exposure were calculated from the baseline and follow-up weekly exposure values, and multiplied by the number of weeks between the completion of the consecutive questionnaires. A correction factor of 0.8 was used in order to account for the seasonal variation in PA participation throughout the follow-up period. Although chosen arbitrarily, this correction factor is in line with the decrease in PA during winter as found in previous studies.^{20 21}

Injury registration

Throughout the follow-up period, PA injuries were continuously monitored by PE teachers. In case of injury, the PE teacher provided the injured child with an injury registration form which had to be completed within 7 days of injury onset, with the help from the PE teacher. On this form, the child was asked to provide information on the injury location, injury

type, injury diagnosis, direct cause of the injury, subsequent medical treatment and activity performed at the time of injury (ie, PE class, leisure time PA or sports).

The injury definition as described by van Mechelen *et al*¹⁴ was adapted for this study. An injury is any injury resulting from participation in PE class, sports activities or leisure time PA with one 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.

Statistical analyses

Statistical analyses were performed using SPSS PASW statistical software, release 18.0. Injury incidence density (IID) and corresponding 95% CI were calculated for the different levels of the categorical variables, as the number of new injuries reported per 1000 h of exposure. Therefore, exposure time of each individual child until the onset of first injury within each specific modality of PA was used. Incidence proportion expressed as the proportion (%) of participants injured was estimated for different levels of the categorical variables. We performed univariate Cox proportional hazard regression analyses, to estimate the HR and 95% CI of the potential injury risk factors. Schools were used as strata to allow for clustering within schools. From these, a multivariate Cox proportional hazard regression model was developed, in which only those potential risk factors that were at the 20% level of significance were included.

RESULTS

Population

Of the 20 schools that agreed to participate in the study, all completed the entire follow-up period. One or more questionnaires were missing for 95 individual participating children. Consequently, these children were excluded from the analyses. This resulted in a sample of 996 children (493 boys and 503 girls) (table 1).

PA-related injuries

During the school year, a total of 119 injuries were reported by 104 children, resulting in an overall IID of 0.48 per 1000 h of exposure (95% CI 0.38 to 0.57) (table 1). IID was lowest for leisure time PA (IID=0.39; 95% CI 0.28 to 0.50), followed subsequently by PE (IID=0.50; 95% CI 0.29 to 0.71) and sports (IID=0.66; 95% CI 0.46 to 0.87).

Risk factor analyses

IID by potential risk factors are presented in table 1. Univariate Cox regression analyses revealed that gender, age and weekly exposure are the factors related to the overall injury risk (table 2). For injuries during leisure time, the PA-related risk factors were gender, ethnicity, SES and weekly exposure. Sports-related injuries were only associated with age, whereas injuries during PE classes did not have any relevant associative risk factors.

The results of the multivariate analyses are presented in table 3. Overall injuries were predicted by gender, age and weekly exposure. Girls were at higher risk of injury (HR 1.60; 95% CI 1.05 to 2.46), and injury risk got higher as age increased (HR 2.62; 95% CI 1.01 to 6.80). Most remarkably

Table 1 Demographic risk characteristics, incidence proportion (%) and IID (95% CI)

	Overall		Leisure time PA		PE classes		Sports	
	N (%)	Injuries (%)	IID (95% CI)	Injuries (%)	IID (95% CI)	Injuries (%)	IID (95% CI)	Injuries (%)
Gender								
Boys	493 (49.5%)	44 (8.9%)	0.35 (0.25 to 0.36)	17 (3.4%)	0.25 (0.13 to 0.37)	13 (2.6%)	0.59 (0.27 to 0.91)	17 (3.4%)
Girls	503 (50.5%)	60 (11.9%)	0.57 (0.42 to 0.71)	31 (6.2%)	0.53 (0.35 to 0.72)	9 (1.8%)	0.41 (0.14 to 0.68)	23 (4.7%)
Age								
9	59 (5.9%)	7 (11.9%)	0.56 (0.15 to 0.98)	3 (5.1%)	0.47 (0.00 to 1.01)	2 (3.4%)	0.82 (0.00 to 1.95)	2 (3.4%)
10	353 (35.4%)	33 (9.3%)	0.39 (0.2 to 0.53)	14 (4.0%)	0.25 (0.12 to 0.38)	8 (2.3%)	0.51 (0.16 to 0.87)	11 (3.1%)
11	454 (45.6%)	45 (9.9%)	0.43 (0.31 to 0.56)	24 (5.3%)	0.43 (0.26 to 0.60)	9 (2.0%)	0.45 (0.16 to 0.74)	16 (3.5%)
12	130 (13.1%)	19 (14.6%)	0.36 (0.35 to 0.92)	7 (5.4%)	0.41 (0.11 to 0.72)	3 (2.3%)	0.53 (0.00 to 1.14)	11 (8.5%)
Ethnicity								
Western	727 (76%)	78 (10.7%)	0.45 (0.35 to 0.56)	35 (4.8%)	0.38 (0.26 to 0.51)	15 (2.1%)	0.47 (0.23 to 0.71)	29 (4.0%)
Non-western	229 (24%)	16 (7.0%)	0.32 (0.16 to 0.48)	6 (2.6%)	0.20 (0.04 to 0.36)	4 (1.7%)	0.39 (0.01 to 0.78)	6 (2.6%)
Missing	40							
Socioeconomic status								
Low	152 (20.3%)	19 (12.5%)	0.54 (0.30-0.79)	9 (5.9%)	0.43 (0.15 to 0.71)	5 (3.3%)	0.74 (0.09 to 1.39)	6 (3.9%)
Medium	234 (31.2%)	24 (10.3%)	0.43 (0.60-0.60)	7 (3.0%)	0.23 (0.06 to 0.40)	6 (2.6%)	0.57 (0.11 to 1.03)	14 (6.0%)
High	364 (48.5%)	42 (11.5%)	0.51 (0.36-0.66)	25 (6.9%)	0.60 (0.37 to 0.84)	7 (1.9%)	0.45 (0.12 to 0.78)	11 (3.0%)
Missing	246							
BMI*								
Q1	236	25 (10.6%)	0.44 (0.26 to 0.61)	12 (5.1%)	0.38 (0.17 to 0.60)	6 (2.5%)	0.58 (0.12 to 1.05)	10 (4.2%)
Q2	238	29 (12.2%)	0.51 (0.33 to 0.70)	12 (5.0%)	0.39 (0.17 to 0.60)	4 (1.7%)	0.38 (0.01 to 0.76)	14 (5.9%)
Q3	237	25 (10.5%)	0.48 (0.29 to 0.67)	11 (4.6%)	0.39 (0.16 to 0.63)	5 (2.1%)	0.48 (0.06 to 0.90)	9 (3.8%)
Q4	236	21 (8.9%)	0.40 (0.23 to 0.57)	10 (4.2%)	0.35 (0.13 to 0.56)	7 (3.0%)	0.67 (0.17 to 1.17)	6 (2.5%)
Missing	49							
MOPER score								
Low	164 (16.6%)	15 (19.1%)	0.47 (0.23 to 0.71)	9 (5.5%)	0.50 (0.17 to 0.83)	3 (1.8%)	0.42 (0.00 to 0.89)	3 (1.8%)
Medium	660 (66.9%)	69 (10.5%)	0.45 (0.35 to 0.55)	32 (4.8%)	0.37 (0.24 to 0.50)	16 (2.4%)	0.55 (0.28 to 0.82)	26 (3.9%)
High	163 (16.5%)	19 (11.7%)	0.47 (0.26 to 0.67)	6 (3.7%)	0.29 (0.06 to 0.52)	3 (1.8%)	0.42 (0.00 to 0.89)	11 (6.7%)
Missing	9							
Weekly exposure*								
Q1: <=5.00 h	254	22 (8.7%)	0.72 (0.42 to 1.02)	9 (3.5%)	0.71 (0.25 to 1.17)	5 (2.0%)	0.44 (0.05 to 0.83)	10 (3.9%)
Q2: 5.01–6.70 h	245	26 (10.6%)	0.55 (0.34 to 0.76)	13 (5.3%)	0.50 (0.23 to 0.78)	6 (2.4%)	0.56 (0.11 to 1.01)	9 (3.7%)
Q3: 6.71–9.00 h	256	26 (10.2%)	0.39 (0.24 to 0.54)	13 (5.1%)	0.33 (0.15 to 0.51)	2 (0.8%)	0.18 (0.00 to 0.42)	11 (4.3%)
Q4: >=9.01 h	241	30 (12.4%)	0.35 (0.22 to 0.47)	13 (5.4%)	0.27 (0.12 to 0.42)	9 (3.7%)	0.87 (0.30 to 1.44)	10 (4.1%)

*Groups represent age- and gender-specific quartiles sampled from the total population.

BMI, body mass index; IID, injury incidence density; MOPER, motor performance; PA, physical activity.

Original article

Table 2 Univariate Cox regression analyses for all potential injury risk factors. HR are adjusted for clustering within schools.

	Overall		Leisure time PA		PE classes		Sports	
	HR (95% CI)	p Value	HR (95% CI)	p Value	HR (95% CI)	p Value	HR (95% CI)	p Value
Gender								
Boys	1	0.004	1	0.013	1	0.785	1	0.617
Girls	1.85 (1.22 to 2.79)†		2.16 (1.18 to 3.80)†		1.13 (0.47 to 2.71)		0.85 (0.44 to 1.62)	
Age								
9	1	0.178	1	0.749	1	0.923	1	0.007
10	1.29 (0.54 to 3.12)		1.18 (0.32 to 4.40)		0.81 (0.14 to 4.53)		1.88 (0.39 to 9.04)	
11	1.44 (0.61 to 3.44)		1.62 (0.45 to 5.85)		0.81 (0.15 to 4.47)		2.72 (0.49 to 10.5)	
12	2.36 (0.92 to 6.06)		1.64 (0.38 to 7.02)		1.27 (0.17 to 9.28)		7.17 (1.48 to 34.85)†	
Ethnicity								
Western	1	0.212	1	0.053	1	0.899	1	0.859
Non-western	0.63 (0.31 to 1.30)		0.17 (0.03 to 1.03)		1.09 (0.27 to 4.42)		0.91 (0.34 to 2.48)	
Socioeconomic status								
Low	1	0.369	1	0.082	1	0.638	1	0.209
Medium	0.64 (0.34 to 1.19)		0.35 (0.12 to 1.01)		0.90 (0.24 to 3.33)		1.04 (0.39 to 2.79)	
High	0.77 (0.42 to 1.42)		0.93 (0.39 to 2.22)		0.53 (0.12 to 2.30)		0.49 (0.17 to 1.46)	
BMI*								
Q1	1	0.501	1	0.689	1	0.786	1	0.337
Q2	1.27 (0.73 to 2.21)		1.21 (0.53 to 2.76)		0.86 (0.23 to 3.23)		1.51 (0.66 to 3.48)	
Q3	1.42 (0.80 to 2.52)		1.45 (0.62 to 3.38)		0.92 (0.24 to 3.48)		1.00 (0.40 to 2.51)	
Q4	0.96 (0.51 to 1.79)		0.88 (0.36 to 2.14)		1.50 (0.46 to 4.89)		0.63 (0.22 to 1.82)	
MOPER score								
Low	1	0.437	1	0.605	1	0.934	1	0.352
Medium	0.69 (0.39 to 1.22)		0.72 (0.34 to 1.53)		1.15 (0.33 to 4.09)		1.50 (0.45 to 5.03)	
High	0.76 (0.38 to 1.52)		0.61 (0.21 to 1.77)		0.93 (0.18 to 4.78)		2.31 (0.63 to 8.51)	
Weekly exposure*								
Q1: ≤5.00 h	1	<0.001	1	0.082	1	0.181	1	0.319
Q2: 5.01–6.70 h	0.20 (0.10 to 0.42)†		0.79 (0.33 to 1.93)		1.25 (0.33 to 4.76)		0.64 (0.25 to 1.61)	
Q3: 6.71–9.00 h	0.06 (0.03 to 0.14)†		0.43 (0.17 to 1.09)		0.42 (0.08 to 2.34)		0.62 (0.25 to 1.52)	
Q4: ≥9.01 h	0.03 (0.01 to 0.07)†		0.34 (0.13 to 0.88)†		2.18 (0.64 to 7.35)		0.39 (0.15 to 1.04)	

*Groups represent age- and gender-specific quartiles sampled from the total population.

†Significant difference compared with reference category.

BMI, body mass index; MOPER, MOPER, motor performance; PA, physical activity; PE, physical education.

it was found that injury risk significantly declined with an increase in weekly exposure; the most active children had the lowest injury risk (HR 0.03; 95% CI 0.01 to 0.07).

Sports-related injuries were significantly associated with age, where injury risk increased with age (HR 7.17; 95% CI 1.48 to 34.85). For leisure time PA, none of the variables were significant risk factors for injury. Although not significant, girls and the least active children were at highest injury risk (table 3).

DISCUSSION

This prospective study carried out during 1 school year showed that in a population of 9–12-year-old children, gender, age and level of PA were independent significant risk factors for injury. In addition, different modalities of PA had different injury risk factors. The most striking finding was that a low habitual PA level had the strongest association with the overall injury risk.

Comparison of incidence figures is inherently hampered by the differences in study design, population and injury definition. A proper comparison is, on this topic, further complicated by the small number of available studies on risk factors for PA-related injuries in children and the relative narrow sports-specific scope most studies have used.²² Our study specifically dealt with injuries in a relative young age group of 9–12-year-old children, and investigated the entire scope of PA modalities these children may participate in.

Since our study comprises secondary data analyses of an existing data set, we have been limited in the array and number of potential risk factors analysed. Another drawback that requires attention is the registration of participation in leisure time PA and sports. Individual exposure to sports and leisure time PA was estimated from the self-reported weekly participation data as reported in the baseline and follow-up questionnaires. Exposure estimations would have been more accurate when measured objectively and on a more regular basis. From a practical perspective, this was not possible. Our less accurate method might have resulted in an overestimation of the actual exposure to leisure time PA and sports. Despite this potential bias, we were able to calculate IID per 1000 h of exposure, giving an estimation of the actual differences in injury risk between the different analysed risk factors.

Although presumably overestimated, the availability of exposure data is also the main strength of this study. Most injury risk studies in children have been using logistic regression or Poisson regression analyses on dichotomous outcomes, that is, injured or not injured.^{22–24} This approach can be performed in a uniform population of children, in which exposure is equal between the subgroups of interest for the analyses. However, in our population, exposure rates, and thus inherent injury risk, differ between analysed subgroups. Merely adjusting for exposure in dichotomous analyses does not account fully for these differences, as we have shown in our study that low levels of exposure are a risk factor by itself.

Table 3 Results of the multivariate Cox regression analyses. HR are adjusted for clustering within schools.

Overall			Leisure time PA			Sports	
	HR (95% CI)	p Value		HR (95% CI)	p Value	HR (95% CI)	p Value
Gender			Gender			Age	
Boys	1		Boys	1		9	1
Girls	1.60 (1.05 to 2.46)†	0.030	Girls	1.99 (0.97 to 4.08)	0.060	10	1.88 (0.39 to 9.04)
Age			Ethnicity			11	2.72 (0.49 to 10.5)
9	1		Western	1		12	7.17 (1.48 to 34.85)†
10	1.17 (0.48 to 2.85)	0.729	Non-western	0.39 (0.06 to 2.66)	0.388		
11	1.29 (0.54 to 3.08)	0.574	Socio economic status				
12	2.62 (1.01 to 6.80)†	0.048	Low	1			
Weekly exposure*			Medium	0.43 (0.14 to 1.30)	0.429		
Q1	1		High	0.36 (2.33 to 0.91)	0.851		
Q2	0.18 (0.08 to 0.38)†	<0.001	Weekly exposure*				
Q3	0.06 (0.02 to 0.38)†	<0.001	Q1	1			
Q4	0.03 (0.01 to 0.07)†	<0.001	Q2	0.68 (0.24 to 1.95)	0.468		
			Q3	0.71 (0.25 to 1.98)	0.511		
			Q4	0.36 (0.11 to 1.15)	0.085		

*Groups represent age- and gender-specific quartiles sampled from the total population.

†Significant difference compared with reference category.

PA, physical activity.

We do acknowledge that a Cox proportional hazard regression approach has also its limitations when looking at weekly exposure as a risk factor. However, IID ratios of the analysed risk factors do show similar outcomes as our approach, albeit less strong. As an example, the IID ratio between the lowest and the highest quartile of weekly exposure is 0.48 (95% CI 0.28 to 0.84). This strengthens us in our belief that our approach is a proper resemblance of the overall association between the studied factors and the injury risk.

Our different analysis approach might, in part, explain the differences between our results and what has been reported in previous literature. Most notably, we found girls to have a higher injury risk than boys (HR=1.60; 95% CI 1.05 to 2.46). This contradicts what is generally being reported in the literature. However, it should be noted that we only found gender to be a risk factor for overall injuries and leisure time PA injuries. Gender did not predict sports-related injuries in our sample, whereas most of the literature reports boys to be at higher sports-related injury risk than girls.^{7 22 25–28} Even though this study is the first to find these gender differences in such a pronounced way, Sorensen *et al*⁶ previously indicated that gender differences in injury risks ‘cross over’ between ages 12 and 14 years. This is presumably due to the growth spurt appearing earlier in girls. It was only in the older ages that Sorensen *et al*⁶ showed injury risk to be substantially higher in boys.

Another striking contrast with the literature is the lack of a relationship between BMI and injury risk. There are sound data that show in children that the risk of sustaining a sports-related injury increases with BMI.^{24 29} This relationship was not established in our cohort. Likely, our sample lacks the power to specifically identify BMI as a risk factor for sports-related injury, as only a relative small part of our population participated in sports. Moreover, those children who did participate in sports generally had a lower BMI than non-participating children. It should also be noted that our sample comprised 10–12-year-old children, a somewhat younger population than being described in previous studies. Even though this age group participates in organised sports, the forms in which they play these sports are likely to be different and less competitive than at later ages. This can also, in part, be

derived from the increased risk of sports-related injuries in the older part of our population.

However, closely linked to high BMI, we did find that low levels of PA had the strongest association with overall injury risk. In other words, the least active children had the highest injury risk. This is a remarkable finding while the analyses have taken exposure to PA into account. One can only sustain a PA-related injury when participating in PA. Although the absolute number of injuries was the lowest in the group of children with the lowest weekly exposure, the actual injury risk was significantly higher. Most notable of this result is that the steepest increase in injury risk was found for the quartile with the lowest habitual PA level, and that the cut-off for this level was 5 h of PA per week. Coincidentally, the current ruling guidelines state at least 60 min of PA per day for children in this age range.²⁸ As such, not complying with the ruling PA recommendations seems to be a risk factor for PA-related injury risk.

This finding is of special importance as sedentary lifestyle habits are a major international public health (PH) problem, not only in adults but also in children.³⁰ It has been well accepted that low levels of PA during early childhood will affect the current and future health and well-being of the population, and promoting PA in younger children is therefore globally a major PH priority.^{30 31} With this strong focus on a physically active lifestyle and the current efforts to increase PA levels in sedentary youth, an increasing number of PA-related injuries can be expected in this high risk subpopulation. Notwithstanding that most PA injuries are ‘minor’ and that the risk of injury will likely reduce on the long-term, the occurrence of PA-related injury can result in pain, disability, school absence, costs and sometimes cessation from otherwise healthy PA activities.³² Therefore, our results indicate that the prevention of PA-related injuries should be an essential part of PA promotion in youth.

CONCLUSIONS

Gender, age and level of PA are independent significant risk factors for PA-related injury in 10–12-year-old children. In addition, different modalities of PA have different injury risk factors. Most importantly, low levels of PA significantly increase the injury risk. The latter is of special importance, as

Original article

these vulnerable children are the target audience of the contemporary PA promotion efforts. Our data show that these efforts should also focus on injury prevention.

Funding The iPlay study is supported by grant 62200033 from The Netherlands Organization for Health Research and Development.

Competing interests None.

Ethics approval Medical Ethics Committee of the VU University Medical Center, Amsterdam, The Netherlands.

Provenance and peer review Not commissioned; externally peer reviewed.

REFERENCES

1. **Eklom B**, Astrand PO. Role of physical activity on health in children and adolescents. *Acta Paediatr* 2000;**89**:762–4.
2. **Hallal PC**, Victora CG, Azevedo MR, *et al*. Adolescent physical activity and health: a systematic review. *Sports Med* 2006;**36**:1019–30.
3. **Janssen I**, Leblanc AG. Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *Int J Behav Nutr Phys Act* 2010;**7**:40.
4. **Hallal PC**, Dumith SC, Reichert FF, *et al*. Cross-sectional and longitudinal associations between physical activity and blood pressure in adolescence: birth cohort study. *J Phys Act Health* 2011;**8**:468–74.
5. **Currie CE**, Williams JM, Wright P, *et al*. Incidence and distribution of injury among schoolchildren aged 11–15. *Inj Prev* 1996;**2**:21–5.
6. **Sørensen L**, Larsen SE, Röck ND. The epidemiology of sports injuries in school-aged children. *Scand J Med Sci Sports* 1996;**6**:281–6.
7. **Abernethy L**, MacAuley D. Impact of school sports injury. *Br J Sports Med* 2003;**37**:354–5.
8. **Sundblad G**, Saartok T, Engström LM, *et al*. Injuries during physical activity in school children. *Scand J Med Sci Sports* 2005;**15**:313–23.
9. **Verhagen E**, Collard D, Paw MC, *et al*. A prospective cohort study on physical activity and sports-related injuries in 10–12-year-old children. *Br J Sports Med* 2009;**43**:1031–5.
10. **Sørensen L**, Larsen SE, Röck ND. Sports injuries in school-aged children. A study of traumatologic and socioeconomic outcome. *Scand J Med Sci Sports* 1998;**8**:52–6.
11. **Collard DCM**, Verhagen EALM, Van Mechelen W *et al*. Economic burden of physical activity-related injuries in Dutch children aged 10–12. *Br J Sports Med* 2011;**45**:1058–63.
12. **Flynn JM**, Lou JE, Ganley TJ. Prevention of sports injuries in children. *Curr Opin Pediatr* 2002;**14**:719–22.
13. **van Mechelen W**, Verhagen E. Essay: Injury prevention in young people – time to accept responsibility. *Lancet* 2005;**366**(Suppl 1):S46.
14. **van Mechelen W**, Hlobil H, Kemper HC. Incidence, severity, aetiology and prevention of sports injuries. A review of concepts. *Sports Med* 1992;**14**:82–99.
15. **Spinks AB**, McClure RJ. Quantifying the risk of sports injury: a systematic review of activity-specific rates for children under 16 years of age. *Br J Sports Med* 2007;**41**:548–57; discussion 557.
16. **Collard DC**, Verhagen EA, Chin A Paw MJ, *et al*. Acute physical activity and sports injuries in children. *Appl Physiol Nutr Metab* 2008;**33**:393–401.
17. **Collard DC**, Chinapaw MJ, van Mechelen W, *et al*. Design of the iPlay study: systematic development of a physical activity injury prevention programme for primary school children. *Sports Med* 2009;**39**:889–901.
18. A standard definition for an immigrant: how does the Central Bureau for Statistics do that? (in Dutch). Central Bureau for Statistics, <http://www.cbs.nl/> (accessed 1 September 2011).
19. **Leyten C**, Kemper H, Verschuur R. *De Moper Fitheidstest: Handleiding En Prestatieschalen 9 T/M 11 Jarigen*. Haarlem: De Vrieseborch 1982.
20. **Tucker P**, Gilliland J. The effect of season and weather on physical activity: a systematic review. *Public Health* 2007;**121**:909–22.
21. **Uitenbroek DG**. Seasonal variation in leisure time physical activity. *Med Sci Sports Exerc* 1993;**25**:755–60.
22. **Emery CA**. Risk factors for injury in child and adolescent sport: a systematic review of the literature. *Clin J Sport Med* 2003;**13**:256–68.
23. **Rose MS**, Emery CA, Meeuwisse WH. Sociodemographic predictors of sport injury in adolescents. *Med Sci Sports Exerc* 2008;**40**:444–50.
24. **McHugh MP**. Oversized young athletes: a weighty concern. *Br J Sports Med* 2010;**44**:45–9.
25. **Bijur PE**, Trumble A, Harel Y, *et al*. Sports and recreation injuries in US children and adolescents. *Arch Pediatr Adolesc Med* 1995;**149**:1009–16.
26. **de Loës M**. Epidemiology of sports injuries in the Swiss organization “Youth and Sports” 1987–1989. Injuries, exposure and risks of main diagnoses. *Int J Sports Med* 1995;**16**:134–8.
27. **Lenaway DD**, Ambler AG, Beaudoin DE. The epidemiology of school-related injuries: new perspectives. *Am J Prev Med* 1992;**8**:193–8.
28. **Zariczyj B**, Shattuck LJ, Mast TA, *et al*. Sports-related injuries in school-aged children. *Am J Sports Med* 1980;**8**:318–24.
29. **Carter CW**, Micheli LJ. Training the child athlete: physical fitness, health and injury. *Br J Sports Med* 2011;**45**:880–5.
30. **Pate RR**, Mitchell JA, Byun W, *et al*. Sedentary behaviour in youth. *Br J Sports Med* 2011;**45**:906–13.
31. **Mountjoy M**, Andersen LB, Armstrong N, *et al*. International Olympic Committee consensus statement on the health and fitness of young people through physical activity and sport. *Br J Sports Med* 2011;**45**:839–48.
32. Department of Health PA. Health Improvement and Prevention: At least five a week. Evidence on the impact of physical activity and its relationship to health. A report form the chief medical officer Report. UK: Department of Health, 2004.



Physical inactivity is a risk factor for physical activity-related injuries in children

Frank Bloemers, Dorine Collard, Mai Chin A Paw, et al.

Br J Sports Med 2012 46: 669-674 originally published online December 14, 2011

doi: 10.1136/bjsports-2011-090546

Updated information and services can be found at:
<http://bjsm.bmj.com/content/46/9/669.full.html>

These include:

References

This article cites 29 articles, 10 of which can be accessed free at:
<http://bjsm.bmj.com/content/46/9/669.full.html#ref-list-1>

Article cited in:
<http://bjsm.bmj.com/content/46/9/669.full.html#related-urls>

Email alerting service

Receive free email alerts when new articles cite this article. Sign up in the box at the top right corner of the online article.

Topic Collections

Articles on similar topics can be found in the following collections

[Health education](#) (345 articles)
[Injury](#) (731 articles)

Notes

To request permissions go to:
<http://group.bmj.com/group/rights-licensing/permissions>

To order reprints go to:
<http://journals.bmj.com/cgi/reprintform>

To subscribe to BMJ go to:
<http://group.bmj.com/subscribe/>