Scand J Med Sci Sports 2013: ••: ••–••
doi: 10.1111/sms.12095

SCANDINAVIAN JOURNAL OF
MEDICINE & SCIENCE
IN SPORTS

Overuse and traumatic extremity injuries in schoolchildren surveyed with weekly text messages over 2.5 years

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Accepted for publication 28 May 2013

The objectives of this prospective cohort study were to report the incidence, prevalence, and duration of traumatic and overuse injuries during a period of 2.5 years and to estimate the odds of injury types. In all, 1259 schoolchildren, aged 6–12, were surveyed each week with an automated mobile phone text message asking questions on the presence of any musculo-skeletal problems and participation in leisure-time sport. Children were examined and injuries classified as overuse or traumatic. The overall injury incidence and prevalence were 1.2% and 4.6% per week, with 2.5 times more overuse than traumatic injuries in lower extremities, and mean injury duration of 5.3 and 4.8 weeks, respectively. A reverse pattern was found for upper extremities, with 3.1 times more traumatic than overuse injuries and mean durations of 3.3 and 5.2 weeks, respectively. Grade level, school type, leisure-time sport, and seasonal variation were associated with the risk of sustaining lower extremity injuries. Only grade level was associated with upper extremity injuries. The magnitude of overuse and traumatic limb injuries emphasizes the need for health professionals, coaches, and parents to pay special attention in relation to the growing and physically active child.

Children gain many health benefits from participating in regular physical activity (PA) (Ekblom & Astrand, 2000; Janssen & Leblanc, 2010; Andersen et al., 2011). Injuries sustained in sports activities have, however, been established as a leading cause of pediatric injuries in Western countries (Finch et al., 1998; Brudvik & Hove, 2003; Conn et al., 2003). Sports injuries in children constitute a significant public health burden, leading to high direct and indirect costs for both children and parents (Collard et al., 2011). Injuries may cause short-term disability, absence from school and PA, loss of enthusiasm for participating in PA, and long-term consequences such as osteoarthritis (Kujala et al., 1995; Mikkelsson et al., 1997; Abernethy & MacAuley, 2003; Oiestad et al., 2010).

Injuries are commonly defined according to injury mechanism, in terms of whether injuries are traumatic or caused by overuse. Traumatic injuries are those resulting from a single, specific, and identifiable event, whereas overuse injuries are caused by repeated microtrauma without a single, identifiable event responsible for the injury (Fuller et al., 2006). There are no studies providing incidence or prevalence of overuse injuries in children and adolescents, whereas data on traumatic injuries are commonly collected in emergency departments but might only reveal "the tip of the iceberg." There is a growing concern about overuse injuries (Brenner, 2007; Mayranpaa et al., 2010) and it has been estimated that approximately half of all sports-related injuries are in fact caused by overuse (Valovich McLeod et al., 2011). It has been speculated that early specialization, increased intensity of training, and competition in sport at younger ages, maybe on multiple teams simultaneously, and often year round, could be a cause for an increased number of overuse injuries (Brenner, 2007; Mayranpaa et al., 2010). Concerns have been raised that the consequences of overuse injury might be more serious to children and adolescents because the growing tissues are particularly vulnerable to stress (Olsen et al., 2006; O'Malley et al., 2012).

There are probably three main reasons why it is difficult to quantify and describe overuse injuries in childhood. First, they can be difficult to diagnose, as symptoms have a vague and gradual onset. Second, their presence may not result in a measurable consequence such as medical care seeking or absence from school or physical activities and third, there has been a lack of valid, reliable, and user-friendly methods for collecting this type of data.

The common use of mobile phones now makes it possible to collect frequent data of self-reported symptoms indicative of musculo-skeletal injuries and amount of PA for long periods in large populations. In this study a large cohort of Danish schoolchildren was monitored closely with frequent and real-time data on musculo-skeletal pain and diagnosed injuries. This provided an opportunity to obtain improved estimates of the prevalence and incidence on both traumatic and overuse injuries.

The objectives of this study were to report the incidence, prevalence, and duration of traumatic and overuse injuries in a Danish cohort of schoolchildren using weekly assessments for 2.5 years and to estimate the odds of injury types when looking at sports participation in school and leisure-time as a risk factor, adjusting for gender, age, previous injuries, and seasonal variation.

Materials and methods

Setting

Data from the Childhood Health, Activity, and Motor Performance School Study Denmark (CHAMPS Study–DK) August 2008 to July 2011 were used (Wedderkopp et al., 2012). This investigation is a large prospective controlled school-based study in Denmark using the design of a natural experiment (Craig et al., 2012) to evaluate the effect of increased physical education (PE) on childhood health in general. Six schools were assigned to become sport schools with six PE lessons per week and four normal schools served as control with two PE lessons per week. Parents and children were unaware of the initiation of this project until 2 months before the following school year, avoiding parents making an influenced school choice. The project is extensively described elsewhere (Wedderkopp et al., 2012).

Ethics committee approval was obtained before the start of the project; ID S20080047 and registration in the Danish Data Protection Agency was made, as stipulated by the law J.nr. 2008-41-2240. Written informed consent was obtained from the child's parent. Prior to every clinical examination, both child and parent gave verbal acceptance. All participation was voluntary with the option to withdraw at any time.

Participants

All boys and girls from preschool to fourth grade in 10 public schools participating in the CHAMPS Study-DK also agreed to participate in the registration of musculo-skeletal pain and injuries. The overall participation rate was 697 (90%) for the sport schools and 521 (71%) for the normal schools. The study was kept open, with the possibility for new children to enter. Due to the novel data collection method of automated mobile phone text message (SMS-track), the 10 schools were included gradually over 8 months to allow for a phasing-in process.

Measurements

Musculo-skeletal pain and injuries

Weekly information on musculo-skeletal pain and injuries was collected using SMS-track. This approach provides real-time measurements and thereby improves the validity of data relative to data collected retrospectively (Shiffman et al., 2008). Each Sunday, parents answered a text message that asked questions on the presence or absence of any musculo-skeletal pain during the previous week. If pain was reported, a telephone consultation was carried out Monday and if the problem still persisted, the complaint was defined as "nontrivial." Physiotherapists, chiropractors, and a medical practitioner were responsible for the clinical examination of the children within the coming fortnight. Injuries were diagnosed using the International Classification of Diseases (ICD-10). If necessary, the child was referred for further para-clinical examination, such as X-ray, ultrasound, or magnetic resonance imaging scan, and possibly seen by a medical specialist. Information on children being seen or treated elsewhere (e.g., emergency department, general practitioner) during the study period was collected concurrently to get a complete data collection on injuries. Collection of data was suspended during the 6 weeks of summer holiday.

A traumatic injury is defined as an injury resulting from a specific, identifiable event, whereas an overuse injury is an injury caused by repeated microtrauma without a single identifiable event responsible for the injury (Fuller et al., 2006). Injuries were classified into these two categories by looking at diagnosis and medical records, where the injury mechanisms were documented.

Sports participation in school and leisure-time

Weekly amount of PE was 4.5 h for sport schools and 1.5 h for normal schools, corresponding to three and one double lesson per week, respectively. Children at sport and normal schools were therefore assigned three and one sport exposure unit per week, respectively. Leisure-time sport was assessed using SMS-track by parental reports on how many times the child had participated in leisure-time sport during the past week.

Socioeconomic information

Socioeconomic information on parental educational level and income was collected in a baseline questionnaire.

Statistical methods

Data from SMS-track and data on diagnosed injuries were analyzed using STATA 12.0 (StataCorp, College Station, Texas, USA).

Excessive levels of pain and injuries were reported during the start-up phase. This is possibly explained by the novelty of the study and the method. Observations from the first 4 weeks relative to the time of inclusion were therefore excluded.

Potential confounders and effect modifiers for the prevalence and incidences of injuries were assessed by exploratory tables and figures. This involved the calculation of observed weekly means of prevalence, incidence, and duration of complaints and injuries. The calculation of injury incidence rates accounted for the total sum of exposure expressed in 1000 athletic exposure units. These comprised the PE exposures and the participations in leisure-time sport.

The selection of potential confounder effects for the analysis included gender, age, and previous injuries, the latter up till 8 weeks prior to index injury. These are commonly acknowledged modifying factors (Emery, 2003; Caine et al., 2008). Plots of observed incidence and prevalence over time indicated a high-risk period during autumn and spring and a low-risk period. Seasonal variation was therefore also included as a potential effect modifier.

The focal point of interest was the risk of the three competing states: no injury, a traumatic injury, or an overuse injury. The analysis aimed at describing how the risk for entering these states depended on the explanatory variables. This was suitably modeled by a multinomial logistic regression extended to the longitudinal and multilevel setting (Steele et al., 2004), using children, classes, and schools as random effects. The multilevel model and the random effects reflect the hierarchical sampling structure and were chosen to allow for potential variation between schools, between classes within schools, and between pupils within classes and ensure correct modeling of the variances. The sources of variation (e.g., environments, teachers, atmosphere) in themselves were not of interest and were therefore deemed to be random effects.

The explanatory variables included school type, leisure-time sport, gender, age, previous injury, and seasonal variation.

Potential patterns for the missing values were addressed by a logistic regression analysis controlling for gender, age, school type, and leisure-time sports effects. Missing values because of practicalities concerning changed or wrong mobile numbers were dropped for analyses.

Results

There was a gradual inclusion of schools starting with 231 children from three schools and ending up including children from all 10 schools 8 months later, with all the schools participating from the start of the 2009–2010 school year. In total, 1259 children participated during the study period. The range of participation time was 1–113 weeks, with 90.2 weeks being the mean value. Dropouts were due to children moving away from the municipality or changing to a nonproject school, but were counterbalanced by new children moving to project schools. Fifteen children dropped out for other reasons, the main one being that answering SMS questions every week was too bothersome. An average weekly response rate of 96.2% was recorded during the study period of 113 weeks. A total number of 109 245 observations were recorded and 4297 (3.8%) were missing. Analysis of missing data did not show any patterns when looking at gender, age, school type, and leisure-time sports. Parental education and income levels were comparable between participating schools in the project.

The overall weekly injury incidence and prevalence rates were 1.2% and 4.6%, respectively. The number of injuries and incidence rate of injuries for athletic exposures are shown in Table 1. In the participating 1259 children, a total of 1229 injuries were registered, of these 794 were overuse injuries and 435 were traumatic injuries. Some children experienced more than one injury; the range was from zero injuries and up to nine episodes of lower extremity (LE) injuries and up to three episodes of upper extremity (UE) injuries. The injury incidence per 1000 athletic exposures for overuse LE and traumatic LE injuries was 3.7 and 3.3, respectively, and 2.3 and 2.7 for overuse UE and traumatic UE injuries, respectively.

The weekly incidence, prevalence, and duration of pain and injuries are shown in Table 2. The ratio of overuse LE injuries to traumatic LE injuries was 2.5 : 1, with mean durations of 5.3 and 4.8 weeks, respectively. The reverse applied for UE injuries, with the corresponding ratio being 1 : 3.1 and mean durations of 5.2 and 3.3 weeks, respectively.

On average, the children participated 1.5 times per week (range 0–7.2) in leisure-time sport. Third and fourth grade had a significant higher mean sports participation in leisure-time, compared with preschool, first and second grade. Children in higher grades also had higher odds of both LE and UE overuse and traumatic injuries, with odds increasing by 20% for each grade level for both types of injuries.

Table 1. Descriptive characteristics of 1259 schoolchildren by five grades followed over 2.5 years with number of injuries, number and percentage of children with injuries, mean athletic exposures in school and leisure-time sport, and injury incidence rate per 1000 athletic exposures

	Preschool	Grade 1	Grade 2	Grade 3	Grade 4	Total
Numbers	224	252	271	249	263	1259
Age (years)	6–8	7–9	8–10	9–11	10–12	6–12
Gender						
Girls	120	134	124	138	145	661
Boys	104	118	147	111	118	598
Overuse injuries						
No. of UE overuse injuries	0	7	7	17	13	44
No. of children (%)	0 (0)	6 (2.4)	6 (2.2)	15 (6.0)	13 (5.0)	40 (3.2)
No. of LE overuse injuries	67	134	182	193	174	750
No. of children (%)	52 (23.2)	89 (35.3)	120 (44.3)	116 (46.6)	113 (43.3)	490 (39.0)
Traumatic injuries						
No. of traumatic UE injuries	12	22	38	28	36	136
No. of children (%)	12 (5.4)	19 (7.5)	34 (12.5)	25 (10.0)	33 (12.6)	123 (9.8)
No. of traumatic LE injuries	30	56	79	62	72	299
No. of children (%)	25 (11.2)	39 (15.5)	55 (20.2)	48 (19.3)	56 (21.5)	223 (17.7)
Sports participation (athletic exposures)						
Mean PE (± SD)	2.2 (± 1.0)	2.2 (± 1.0)	2.2 (± 1.0)	2.2 (± 1.0)	2.1 (± 1.0)	2.2 (± 1.0)
Mean leisure-time sport (± SD)	1.0 (± 1.1)	1.4 (± 1.4)	1.6 (± 1.5)	1.8 (± 1.6)	1.8 (± 1.7)	1.5 (± 1.5)
Overuse injuries per 1000 athletic exposures						
UE (95% CI)	0	2.4 (0.6–4.2)	2.0 (0.5–3.4)	2.7 (1.2–3.3)	2.7 (1.2–4.1)	2.3 (1.6–3.0)
LE (95% CI)	3.7 (2.8–4.6)	3.8 (3.2–4.5)	3.6 (3.1–4.1)	3.8 (3.3–4.4)	3.7 (3.2–4.3)	3.7 (3.5–4.0)
Traumatic injuries per 1000 athletic exposures						
UE (95% CI)	2.7 (1.2–4.2)	2.8 (1.6–4.0)	2.9 (1.9–3.8)	2.7 (1.7–3.6)	2.6 (1.7–3.4)	2.7 (2.3–3.2)
LE (95% CI)	3.6 (2.3–4.8)	3.6 (2.7–4.6)	3.2 (2.5–4.0)	3.0 (2.2–3.7)	3.2 (2.5–4.0)	3.3 (2.9–3.6)

CI, confidence interval; LE, lower extremity; PE, physical education; UE, upper extremity.

Table 2. Weekly mean incidence, prevalence, and duration of musculo-skeletal pain and injuries in total group of 1259 participants in SMS-track during 2.5 years of weekly registration

	Weekly mean incidence in percentage (± SD)	Weekly mean prevalence in percentage (± SD)	Mean duration in weeks (± SD)
Lower extremity			
Reported pain	3.2 (± 17.6)	8.8 (± 28.4)	2.8 (± 4.5)
Injury	1.0 (± 9.7)	4.1 (± 19.9)	5.0 (± 7.1)
Overuse injury	0.7 (± 8.2)	3.2 (± 17.7)	5.3 (± 7.7)
Traumatic injury	0.3 (± 5.2)	1.1 (± 10.4)	4.8 (± 7.2)
Upper extremity			
Reported pain	0.7 (± 8.2)	1.3 (± 11.1)	2.2 (± 4.5)
Injury	0.2 (± 4.0)	0.5 (± 7.2)	3.8 (± 8.3)
Overuse injury	0.04 (± 2.0)	0.2 (± 4.9)	5.2 (± 13.6)
Traumatic injury	0.1 (± 3.5)	0.3 (± 5.8)	3.3 (± 4.6)

Table 3. Adjusted odds ratio estimates by injury types for all included covariates

	Lower extremity		Upper extremity	
	Traumatic injuries OR (95% CI)	Overuse injuries OR (95% CI)	Traumatic injuries OR (95% CI)	Overuse injuries OR (95% CI)
Leisure-time sport				
0	1	1	1	1
Increasing per exposure	1.2 (1.1–1.3)*	1.2 (1.1–1.3)*	1.1 (0.96–1.3)	1.1 (0.9–1.4)
School type				
Normal school	1	1	1	1
Sports school	1.6 (1.0–2.5)*	1.3 (0.9–1.9)	1.3 (0.8–1.9)	1.8 (0.9–3.5)
Gender				
Girls	1	1	1	1
Boys	1.0 (0.7–1.3)	0.89 (0.7–1.1)	0.7 (0.5–1.01)	0.7 (0.4–1.2)
Age groups (grade level)				
Preschool (6 years)	1	1	1	1
Increasing per year	1.2 (1.1–1.3)*	1.2 (1.1–1.3)*	1.2 (1.0–1.3)*	1.6 (1.3–2.0)*
Previous injuries				
0	1	1	1	1
Previous injury	1.0 (0.4–2.6)	0.5 (0.3–1.2)	1.4 (0.1–21.3)	4.3 (0.3–65.3)
Season				
Low-risk season	1	1	1	1
High-risk season	1.4 (0.99–2.0)	1.9 (1.5–2.4)*	1.1 (0.7–1.7)	2.0 (0.9–4.8)

*Statistical significance based on $P < 0.05\%$.
CI, confidence interval; OR, odds ratio.

The multilevel adjusted odds ratios by injury types are summarized in Table 3. With normal school as reference, the children in sport schools increased the odds significantly by 60% for traumatic LE injury. No other differences were found between normal and sport schools. Each additional time a child participated in leisure-time sport, the odds for an overuse and a traumatic injury increased by 20%. The odds of sustaining an overuse LE injury increased significantly by 90% in high-risk season. Only age was associated with UE injuries, with odds for traumatic and overuse UE injuries increasing by 20% and 60%, respectively, for each step in grade level. Summing up, age showed a significant association across both injury types on both LE and UE injuries (Fig. 1).

Discussion

This study is to our knowledge the first to report numbers of overuse and traumatic limb injuries, their duration, and the association with sports participation, gender, age, previous injuries, and seasonal variation in a prospective cohort study of schoolchildren. A high number of 1229 injuries were diagnosed in 1259 children and close to twice as many overuse injuries (794) as traumatic injuries (435). Injuries at the lower extremities were the most common, with 1049 LE injuries versus 180 UE injuries. The incidence and prevalence rates of injuries were 1.2% and 4.6% per week and the average duration of the injuries varied from 3.3 to 5.3 weeks, with overuse injuries having the longest duration. Previous recommendations for a standardized methodology to quantify overuse injuries in sports have mentioned the advantage of frequent and prospective measurements, using sensitive scoring instruments to measure pain symptoms and define injuries by other means than time lost from sport or the need for medical attention (Bahr, 2009). This study followed a cohort of children for 2.5 years with weekly recordings on incidence and

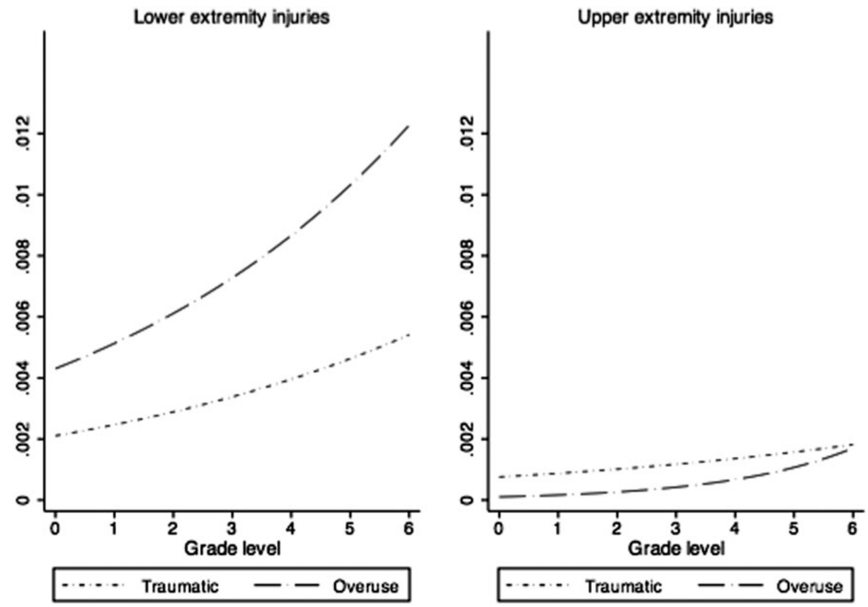

Fig. 1. Adjusted probability of traumatic and overuse LE and UE injuries in relation to grade level. LE, lower extremity; UE, upper extremity.

prevalence of musculo-skeletal pain and injuries and severity based on diagnosis and duration of pain.

A study on a Dutch school cohort reported acute injuries incidence rate of 0.46 (Bloemers et al., 2012). The findings in the present study therefore appear high when taking into account the variation in how physically active children were by means of PE classes and organized sport in leisure-time (overuse injuries: 3.01, acute injuries: 2.99). One of the differences is that exposure hours reported in the Dutch study also included self-reported hours of being physically active in leisure-time outside organized sports participation. This resulted in lower rates of injuries measured per 1000 exposure hours. Incidence rates in this study were more comparable to sports-specific studies (Caine et al., 2008; Moller et al., 2012). The lack of information on nonorganized PA is a limitation to this study, when taking exposure time into consideration.

The relatively high number of injuries and injury rates in this study might also be due to the registration method using weekly text messages to gain knowledge about children possibly having sustained an injury. It could be argued that the numbers and rates were high because of the prospective, frequent, and sensitive monitoring, compared with studies using methods where injuries are registered retrospectively. The possible issue of parents reporting events that would normally be ignored was dealt with by a telephone consultation as a first screen between trivial complaints and persisting symptoms in relation to injury. If the latter was the case, a clinical examination, and if needed, para-clinical investigations and/or further examination by medical specialists was carried out before an injury was finally defined. It was a strength to this study that parental reporting on pain and injuries was validated through objective examinations by clinicians.

Risk of injuries consistently increases with age across most studies when looking at specific sports (Emery, 2003; Caine et al., 2008). This pattern was reproduced in this cohort of children with a broad diversity in choice of sports, amount of participation, competitive levels, etc. This suggests increasing age as a robust risk factor and although not modifiable, age should be considered when targeting groups of children and adolescents for injury prevention.

Previous studies have found evidence that males are generally at higher risk of injury in child and adolescent sport (Emery, 2003; Caine et al., 2008). We found no association between gender and overuse and traumatic injuries. This may be explained by the heterogeneity of the cohort and because it was not selected by any specific clinical condition or sports. Furthermore, it could be speculated that gender differences in injury patterns are more pronounced after puberty, because of the developmental differences in physique.

Previous injuries have shown to be one of the most consistent risk factors for sustaining new injuries, with relative risks ranging from 2.88 to 9.41 (Emery, 2003). These findings are from studies of adults where a previous injury has been defined as an incidence that has caused time lost from sport or the need of medical attention (Emery, 2003; Caine et al., 2008). This motivated the adjustment for previous injuries but it appeared to have no influence on the risk of sustaining a new injury. Possible explanations could be differences in definitions of previous injuries and different methods of sampling across studies. It could also be speculated that most children are not marked by potential implications of inadequate rehabilitation after an injury to the same extent, as could be the case for adults.

In this study, the risk of sustaining overuse LE injuries almost doubled in high-risk periods of season (autumn and spring). Previous studies have suggested that the different levels of PA partly explain the variation in number of injuries across seasons (Tucker & Gilliland, 2007). The proposition of seasonal variation being a proxy measurement for levels of sport participation was ruled out, as there were no indications of colinearity. Other potential extrinsic risk factors include weather conditions, training surface/field conditions, time of season in relation to level of physical fitness, etc., which might explain the difference in risk. The assessment of injuries and seasonal variation was weakened by the lack of recordings during the 6-week period of children's summer holiday.

Repeated data collection inevitably implies missing data. In this study a surprisingly low percentage (3.8%) of the answers were missing. One reason could be the mutual benefit of parents getting their children clinical examined if required and researchers getting answers. Using a mobile texting method as the SMS-track system in research is still a novel method, but has so far proven valid, reliable, feasible, and user-friendly, with high compliance rates (Alfven, 2010; Johansen & Wedderkopp, 2010; Axen et al., 2012; Moller et al., 2012).

Perspectives

This study has shed further light on the area concerning the magnitude and patterns of overuse and traumatic injuries in children and underlined the need to pay special attention to the risks related to the growing, physically active child. The generalizability of the findings in this nonclinical, heterogenic cohort of schoolchildren gives suggestions for focus areas in public health, among practitioners and for increased injury prevention and implementation research. Emery et al. (2006) have emphasized the need for policy-based strategies and for sports organizations, health professionals, coaches, and parents to show responsibility to child sport injury prevention. Our results concerning overuse injuries and the risk factors involved in the etiology of overuse injuries confirm the need for guidelines and recommendations on the prevention of overtraining, burnout, and overuse injuries in children and adolescents as suggested by Brenner (2007) and Valovich McLeod et al. (2011).

Key words: children, short message service (SMS), overuse injuries, traumatic injuries, incidence, prevalence, incidence rate.

Acknowledgements

The authors wish to acknowledge K Froberg and LB Andersen, Research in Childhood Health, University of Southern Denmark. The authors thank the participants and their parents and the participating schools, the Svendborg Project, and the municipality of Svendborg. Finally, the authors wish to acknowledge the members of the CHAMPS Study-DK not listed as coauthors of this paper: T Junge, M Heidemann, and NC Møller.

This study was supported by grants from the IMK Foundation, the Nordea Foundation, the TRYG Foundation – all private, non-profit organizations that support research in health prevention and treatment – and TEAM Denmark, the elite sport organization in Denmark that provided the grant for the SMS-track system.

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