Trifonov Rexen, C., Andersen, L. B., Ersbøll, A. K., Jespersen, E., Franz, C., Wedderkopp, N. (2014). Injuries in children with extra physical education in primary schools. *Medicine & Science in Sports & Exercise, 46*, 745-752.

Title:
Injuries in children with extra physical education in primary schools

Corresponding author:
Christina Christiansen
Chiropractor, Ph.D. student
Centre of Research in Childhood Health
Institute of Sports Science and Clinical Biomechanics
University of Southern Denmark
Campusvej 55, 5230 Odense M, Denmark

Tel.: +45 2671 9691
Fax: +45 6550 3480
E-mail: cchristiansen@health.sdu.dk

Authors:
Christina Christiansen[1], Lars Bo Andersen[1,2], Eva Jespersen[1], Claudia Franz[1], Annette Kjær Ersbøll[3,] and Niels Wedderkopp[1,4,5]

Affiliations:
1 Centre of Research in Childhood Health, Institute of Sports Science and Clinical Biomechanics, University of Southern Denmark, Campusvej 55, DK-5230, Odense M, Denmark.
[2] Department of Sports Medicine, The Norwegian School of Sport Sciences, Oslo.
[3] National Institute of Public Health, University of Southern Denmark, Øster Farimagsgade 5A, 2. Floor, 1353 København K, Denmark
[4] Sport Medicine Clinic, Orthopedic Department, Hospital of Lillebaelt
[5] Institute of Regional Health Services Research, University of Southern Denmark

Conflicts of Interests and Source of Funding:
This study was supported by grants from The IMK Foundation, The Nordea Foundation, The TRYG Foundation - all private, non-profit organizations, which supports research in health prevention and treatment, and TEAM Denmark, the elite sport organization in Denmark, that provided the grant for the SMS-track system. All authors declare no conflicts of Interest.

Abstract:

Purpose (1) Examine the influence of extra physical education (EPE) on the number of musculoskeletal injuries in public schools accounting for organized sports participation (OSP) outside school. (2) Examine the major injury subgroup: growth-related overuse (GRO) through the overuse-related injury group.

Methods A longitudinal school-based natural experiment. In total 1216 children participated aged 6.2-12.4 years. Six schools (701 children) with EPE and four control schools (515 children) were followed with weekly-automated mobile phone text messages for information on musculoskeletal problems and OSP. Healthcare personnel diagnosed the children. Data were analyzed using a two-part model; zero-inflated negative binomial regression.

Results School-type had no influence on odds of sustaining an injury but increased the probability of sustaining a higher injury count if the child belonged to the group of children with injuries; total injuries and overuse by a factor 1.29 (SD 1.13), GRO 1.38 (SD 1.17). Weekly mean OSP decreased odds of belonging to the group with no injuries by a factor 0.29 (SD 0.28), 0.26 (SD 0.25) and 0.17 (SD 0.16) – total, overuse and GRO respectively. OSP also increased the probability of sustaining a higher injury count for the children with injuries by a factor 1.11 (SD 1.12), 1.10 (SD 1.11), and 1.14 (SD 1.14).

Conclusions Children enrolled in EPE-schools with high OSP have the highest odds of injury and a high probability of sustaining a higher injury count compared to their peers at schools with normal PE. Special attention should be assigned these children during the compulsory PE.

Keywords:
Children’s injuries
Children and exercise
Children and adolescents
School intervention

INTRODUCTION

Paragraph 1: Health related benefits of regular engagement in physical activity (PA) in the population are widely known and include decreased risk of cardiovascular disease, obesity, diabetes mellitus type II, and osteoporosis. Physical education (PE) in school is an important arena for PA, because it is compulsory in most countries and therefore includes the least active children (17). In Denmark, the number of schools with increased amount of PE, referred to as "sport schools", is increasing. In May 2011, 38 sport schools (2.8%) existed spread across 18 municipalities in Denmark. The total number of students in those schools were 10,315, an increase of 24% compared to May 2010 (34). There are roughly two different types of sport schools. One type of sport schools have general sports classes from preschool to 6^{th} grade, with broad and all-round PE and the goal of increasing the overall fitness and health, both in the short and long term (21 schools). The second type of sport schools have sports classes from 7^{th} to 9^{th} grade with more specific PE to support talents in specific sports in their development (21 schools). From the total 38 schools, some have both types. Six schools are located in the municipality of Svendborg (May 2011). Although this setting is specific to Denmark, the applicability of an increased amount of PE in a school setting would be possible in most countries.

Paragraph 2: A major drawback of enlarged engagement in sports and PA is the increased risk of sport related injuries, both during PE-classes in school but also during participation in organized sport and PA in leisure time (37). It has been speculated that an increasing number of children undertake intensive physical training at younger ages or participate in multiple sports, increasing the overall exposure. In some cases leaving too little time for tissue remodeling and growth, leading to increased risk of acute and overuse injuries (1, 14). A polarization in sport activity between children in Denmark is seen in the period 1997 to 2007 with a decline in children participating in sport (89% to 84%) and an increase in children spending at least 4 hours per week on sport (44% to 53%) (31).

Paragraph 3: Overuse injuries have been reported to account for up to 50% of all injuries in children and adolescents (11, 39). Growth-related overuse (GRO) injuries are a major subgroup of injuries in the growing individual (20, 27). Osgood-Schlatter's disease, Sinding-Larsen Johansson's disease and Sever's disease are examples of typical GRO-injuries, to the apophyseal centre of ossification, at the point of attachment of a major musculotendinous unit to bone, also called traction apophysitis (26, 33). Traction apophysitis usually occurs during periods of rapid growth, when the growing and ossification of cartilage occurs at locations involved in considerable and repetitive tension forces from pulling muscles (27, 29). Overuse injuries in children and adolescents may be the result of training error, excessive training with increased intensity and inadequate rest, the growth process combined with repetitive training, improper technique, muscular imbalance, participation in multiple sports or early specialization (5, 14, 27).

Paragraph 4: Sport related injuries have negative short- and long-term effects. On the short term, injuries lead to pain, disability, decreased socialization, and participation in sports. Injuries related to joints e.g. cartilage, ligaments, and joint capsules increase the risk for development of secondary osteoarthritis, permanent loss of function, absence from work later in life, and significant health-care cost (21, 35).

Paragraph 5: Increasing the amount of PE-lessons in public schools has several important potential health-related benefits. However, increasing the amount of PE-lessons in public schools may have ethical considerations. The overall outcome of interest is improved health, therefore the drawbacks must be minor and exceeded by improved health for the continuation and expanding of public schools with extra PE-lessons. In this setting, the injuries are the obvious concern. If increased amount of PE-lessons shows increased risk of injuries, then the severity and extent have to be evaluated to ensure the ethical concerns of the concept.

AIMS

Paragraph 6: To investigate the influence of extra PE in public schools on the number of injuries, adjusted for participation in organized sport to account for the total organized exposure, for each child. Further to investigate the major injury subgroup: growth-related overuse injuries through the injury group of overuse-related injuries.

MATERIALS AND METHODS

Study population

Paragraph 7: Ten public schools in the municipality of Svendborg, Denmark, were investigated. Six schools had extra PE (EPE) with 270 min/week and four schools had the normal amount of 90 min/week. Schools with EPE were planned by the municipality, in cooperation with the schools, and were matched with four schools with normal physical education (NPE) based on size and geography - hence a natural experiment (10). This study was a sub-study of "The Childhood Health, Activity, and Motor Performance School Study Denmark" (The CHAMPS-study DK) (40). The children were followed for 2 years. In August 2009, 1216 children participated (NPE: 515, EPE: 701). The project was continuously open for new participants.

PE-lessons on EPE-schools

Paragraph 8: To insure optimal quality of the PE-lessons, PE-teachers and pedagogues participated in a 40-hour course in "Age-related concepts of training" by Team Denmark, which was held to ensure targeted and responsible training for the growing individual (32). Furthermore, a handbook was provided with inspiration for the content of PE lessons with practical suggestions and exercises (3).

Short Messaging Service (SMS)

Paragraph 9: Injuries and organized sports participation (OSP) were derived from a weekly "SMS-Questionnaire" (SMS-track, New Agenda Solutions version 2.1) (28). The method functions as a "follow up" procedure and is used to investigate the fluctuations in complaints from the musculoskeletal system and sports participation over time. Parent reports were used as proxy for the children's response and considered appropriate in this cohort, as self-report questionnaire in young children has shown to be unreliable (4). Previous studies have shown SMS-track to be more reliable and cheaper compared to repeated paper-based surveys with recall over longer periods of time (19). A Swedish study has found the SMS-track system among low back patients aged 16 to 69 years in the primary care sector as user friendly with high response rates (82.5%) unaffected by season (2).

Paragraph 10: The questions used in the present study were automatically sent to the parent's mobile phone at the end of each week asking two questions on different SMS'es:

Question 1: *"Has (the child's name) during the last week had any pain?"* with answer possibilities of 1: neck, back or low back, 2: shoulder, arm or hand, 3: hip, leg or foot or 4: no my child has not had any pain.

Question 2: *"How many times did (the child's name) engage in sports during the last week?"* With answer possibilities of 0: none, 1: once, 2: twice…. 8: more than seven times.

The returned answers were automatically recorded in a database distributed by SMS-track, New Agenda Solutions (28). To improve compliance rate, a reminder was automatically sent, if participants had not responded within 72 and 120 hours after receiving the first message. Furthermore, the respondents were contacted by phone if the answer did not meet the instructions.

Paragraph 11: The answer rate for SMS-track question 1 was 92.19% (5.75% missing answers, 1.63% technical errors, 0.36% invalid answers and 0.07% empty answers). For SMS-track question 2 the answer rate was 92.10% (5.52% missing due to unanswered question 1, 1.58% technical error, 0.53% missing answers, 0.22% invalid answers and 0.05% empty answers).

Data on injuries

Paragraph 12: Data on injuries as the number of ICD-10 diagnoses (International Classification of Diseases, WHO) were collected based on "SMS-track". Parents of children reporting any pain in the past week were contacted by phone by researchers with healthcare education (physiotherapists or chiropractors). The child was examined if an injury was possible. Occasionally the child had already been, or was to be, examined by other healthcare units and the information was then collected (e.g. Emergency Departments, specialists or Hospitals). The injury definition in this study was any ICD-10 diagnosis related to the musculoskeletal system.

The term "GRO-injuries" is used for the group of non-traumatic injuries observed in the growing individual related to the growth zones in the extremities. The International Classification, WHO defines this injury group "chondropaties" comprising the ICD-10 groups M91-M94 (41). From those, the injuries around the knee and heel show similar etiology with traction-apophysitis of the calcaneus, patella, and tuberositas tibiae.

Data on organized sports paticipation

Paragraph 13: Organized sports participation (OSP) in leisure time was collected through SMS-track. The analyses were corrected for OSP in leisure time, since participation was expected to play a significant role in the exposure of possible injuries.

Ethics

Paragraph 14: The study was carried out in accordance with the Declaration of Helsinki and was approved by the local scientific ethics committee (ID S20080047) and registered in the Danish Data Protection Agency (J.nr. 2008-41-2240). Parents of the children gave written informed consent and the children gave verbal consent.

Outcome measures

Paragraph 15: In this study the total number of experienced injuries for each child was of interest. Diagnoses made by the research team with healthcare background and from other healthcare units were summarized for each child and further divided into subgroups with counts of overuse and GRO-injuries. GRO consisted of Calcaneal apophysitis, Osgood-Schlatter, and Sinding-Larsen-Johansson disease (ICD-10 M92.8, M92.5 & M92.4).

Statistical analysis

Paragraph 16: A total of 1305 children participated in the study of which 1206 were included at baseline, August 2009, and 99 were included by drop-in. Forty-one children did not participate in SMS-track, 33 had only missing answers and 3 children had only invalid answers. A minimum participation of 60% answers, of the possible 87 weekly answers on OSP, was used as inclusion in analyses leading to exclusion of 166 children (NPE=66, EPE=100 corresponding to 13% and 14% of all children at NPE- and EPE-schools respectively).

Analyses were performed for the outcomes: total injury count, overuse-related injury count, and GRO-injury count with school-type as primary explanatory variable and OSP, sex, and grade level at baseline as co-variables. OSP was used as mean sports participation per week for each child. The number of injuries was heavily skewed to the right and contained a high proportion (40.3%, 50.5% and 69%) of zero counts. Initially, a graphical visualization was performed investigating how well the outcomes fitted both a Poisson and a negative binomial distribution. Overall, the negative binomial distribution seemed to fit data better than the Poison distribution. Also, Poisson models were not considered appropriate since the mean and variance were not equal, but differed with a factor 1.3 to 1.9. The data structure was hierarchical with three levels with children nested within classes nested within schools. Initially, a three-level Poisson regression model for each of the three outcome measures (number of injuries) was fitted with school, classes within school, and children within classes as random effects. The baseline grade level was included as a fixed effect at class level and school-type (EPE, NPE) was included as a fixed effect at school level. The models had a poor fit due to the high proportion of zero counts and unequal mean and variance in data. Lachenbruch suggests a two-part model (zero-inflated model) for semi-continuous data mixing a discrete point mass at zero (injury count equals zero) and a continuous random variable (1-10 injuries) when the data shows clumping at zero (23). Count outcomes such as number of injuries are often characterized by a large proportion of zeros. Zero-inflated models (as the zero-inflated negative binomial model) are specifically developed for analysis of count outcomes with excess zeros in order to get better insights into the investigation of the factors associated with the outcome. Alternatives to this modelling approach include a logistic regression of injuries categories as a binary variable (injury: yes, no) with loss of information regarding the number of injuries for students with more than one injury. The zero-inflated models can examine the effect of the explanatory variables and covariates in a model, simultaneously modelling the risk of getting an injury and the number of injuries. A zero-inflated negative binomial model was fit to the data (ZINB). The multi-level data structure was accounted for by using a robust variance estimator. Data were analyzed using

STATA® (version 11.1) and a 5% significance level. Backward elimination of non-significant co-variables was performed. However, these models were compared with alternative models since backward elimination is problematic in zero-inflated models favoring the inflate-part over the negative binomial-part. Model choice was based on plots visualizing differences between observed and predicted values, choosing the model with the best model fit supported with the Voung test (24, 38). Two interactions were found in the analyses of GRO-injuries, one between sport mean and grade level in the inflate part of the model giving a more complicated model without improved model fit or interpretation. Another interaction was found between sport mean and sex in the negative binomial part of the model leading to a decrease in model fit without notably added information.

Results

Paragraph 17: Table 1 and figure 1 summarize the analyzed study population. In total 1062 children had 1416 injuries, including 1005 overuse-related injuries of which 454 were GRO-injuries. Participation in organized sport (figure 2) was surprisingly low at EPE schools underlining the importance of adjusting the statistical models for this effect when investigating school-type differences in injuries. Coefficients for the final ZINB models are shown in table 2, separated into the logistic and the negative binomial part of the model.

Total injuries and overuse-related injuries

Paragraph 18: School-type had no effect on the odds of getting injured or not (logistic part of the models). For each additional OSP per week the odds of belonging to the group of children with no injuries decreased by a factor 0.29 and 0.26 respectively holding all other variables constant (total; 0.29 (SD 0.28), overuse; 0.26 (SD 0.25)).

Looking at the group of injured children (the negative binomial part of the models) EPE school-type increased equally the probability of sustaining a higher number of injuries compared to their peers at NPE-schools by a factor 1.29 (SD 1.13). OSP increased the expected injury count almost equally (total; 1.11 (SD 1.12), overuse; 1.10 (SD 1.11)). Girls had a higher injury count than boys, especially for overuse injuries (total; 1.10 (SD 1.10), overuse; 1.23 (SD 1.11)).

Growth-related overuse injuries as subgroup

Paragraph 19: School-type had no effect on the odds of getting a GRO-injury or not (logistic part of the model). Again, for each additional OSP per week the odds of belonging to the group of children with no GRO-injury decreased by a factor 0.17 (SD 0.16) holding all other variables constant. Looking at the group of children with GRO-injuries (the negative binomial part of the model) EPE school-type increased the probability of sustaining a higher number of GRO-injuries by a factor 1.38 compared to their peers at NPE-schools (SD 1.17). OSP was borderline significant (P=0.051); however, OSP increased the expected injury count almost equally compared to the count models for the total injuries and overuse injuries (GRO-injuries; 1.14 (SD 1.14)). No effect of sex was found.

The difference in accumulated probability of experiencing one or more injuries as weekly OSP varies is shown in figure 3. A higher mean OSP resulted in a higher probability of injuries. The school-type difference is most pronounced for GRO-injuries as weekly OSP increases.

Paragraph 20: Six diagnoses in the category of “ICD-10 Chondropathies” were not analyzed together with the GRO-injuries, which only counted apophysitis at the heel and knee. The six injuries consisted of three children with M93.9 "Osteochondropathy, unspecified", two had osteochondrosis related to the upper extremities (M92.0 & M92.2), and one had juvenile osteochondrosis of pelvis (M91.0, iliac crest). All six additional osteochondroses were self-limiting.

Discussion

Paragraph 21: Our data and analyses identified 59.7% children with injuries during the 2-year period. The proportion of children with overuse-related injuries was consistent with earlier estimations of overuse-related injuries, estimated to account for approximately 50% of all pediatric injuries (36). GRO-injuries to the heel and knee were identified to be the largest sub-group of all injuries with a similar etiology (32% of all injuries). Although not serious compared to fractures, sprains, and more severe GRO-injuries, any injury is considered important in a health perspective and in the prevention of lifestyle related diseases through education in an active lifestyle (7, 8, 12, 15, 16, 25). Also severe injuries as a group have a more non-uniform etiology and prevention compared to e.g. the analyzed GRO-injuries. Evaluation of the increased amount of PE-lessons in schools may include advises on further education of PE-teachers, e.g. knowledge about the very common GRO-injuries.

Paragraph 22: Especially sports involving a high rate of physical contact, jumping, sprinting, and pivoting have been shown to cause injuries in children and adolescents (6, 13). LaBella et al. found that a 20-min. neuromuscular warm-up program reduced noncontact lower extremity injuries in female high school soccer and basketball athletes (22). Collard et al. investigated an 8-month school-based injury prevention program among children aged 10-12 years with no overall significant findings. However the low active children showed an intervention effect (9). In general comprehensive warm-up with neuromuscular control, balance, flexibility, strength, technique, and agility drills fitted to the following activity have shown preventive effect in various combinations (18, 30, 36).

Paragraph 23: Alternatives to ordinary exercises may be a way to prevent injuries provoked in the mandatory PE-lessons. Differential activities will allow children with present overuse pain on high intensive or prolonged activities to participate in the PE-lessons.

With the believed etiology and general injury prevention in mind, alternative activities with emphasis on technique, coordination, and precision, without repetitive tensile forces through the major muscle-groups over knee and heel, would be a reasonable suggestion.

Paragraph 24: Our results identified the active children at schools with EPE to have the highest probability of a high injury count. It is important to be aware of the overall exposure. Children are exposed through 1) PE-lessons at schools, 2) organized sports participation and 3) non-organized physical activity including activities in school breaks and leisure time. This means that active children who engage in multiple sports or are training at high level outside school are exposed to an even higher training load than usual and, maybe more important, have less time between activities to recover. Special attention should be placed on these children during the compulsory PE.

Paragraph 25: An advantage of the present intervention is that it is easily implementable outside the reseach environment, increasing the transmissibility to everyday life. A possible bias in this study is over-reporting of pain during the weekly SMS questionnaire leading to over-diagnosis of injuries. However the chiropractors and physiotherapists were aware of this issue and each ICD-10 diagnosis were made based on the presence of relevant clinical findings only. We assume equal report behavior on injuries between the school-types based on the very high answer rate of the weekly SMS-track (10.01% missing on NPE-schools, 6.17% missing on EPE-schools) and an overall mean of 80.7 answer weeks out of 87 possible.

Strengths and limitations

Paragraph 26: A major strength in this study is the repeated measurement of injuries and organized sports participation. Other strengths are the professional evaluation of injuries and the high participation and response rates. Limitations are missing information on participation rate in PE-lessons and non-organized leisure time activity. Measurements of PA by accelerometry may increase the information about overall exposure.

Conclusions

Paragraph 27: Sixty percent of all children experienced one or more musculoskeletal injuries. GRO-injuries to the knee and heel accounted for 32% of all injuries and were identified as the largest subgroup of injuries with a similar etiology. Children enrolled in schools with EPE and a high OSP have the highest odds of injury and a high probability of sustaining a higher injury count compared to their peers at schools with the normal amount of PE. Special emphasis should be placed on these children during the compulsory PE in schools.

Competing interests

Paragraph 28: All authors state that they have no competing interest.

Acknowledgements

Paragraph 29: The authors gratefully acknowledge the work of students and PhD students who have participated in the data collection for the CHAMPS-study DK. We thank children, parents and teachers in the schools involved in the project, and we are grateful for the cooperation with "Elitesekretariatet" in the municipality of Svendborg.

Funding

Paragraph 30: This study was supported by grants from The IMK Foundation, The Nordea Foundation, The TRYG Foundation - all private, non-profit organizations, which supports research in health prevention and treatment, and TEAM Denmark, the elite sport organization in Denmark, that provided the grant for the SMS-track system.

Contributor ship statement:

Paragraph 31: Study design: CC, LBA, EJ, CF, and NW. Study conduct: CC, EJ, and CF. Data collection: CC, EJ, and CF. Data interpretation: CC, AKE, and LBA Drafting manuscript: CC, LBA, and AKE. Revising content: CC, LBA, EJ, CF, AKE, and NW. Approving the final version of the manuscript: CC, LBA, EJ, CF, AKE, and NW. CC takes responsibility for the integrity of the data analyses.

What are the new findings?

- Children enrolled in schools with extra PE and a simultaneous high organized sports participation have the highest odds of injury and a high probability of sustaining a higher injury count compared to their peers at schools with the normal amount of PE.
- Special attention should be placed on these children during the compulsory PE.
- Growth-related overuse injuries is a major subgroup of injuries with a similar etiology in young school-aged children.

How might it impact on clinical practice in the near future?

- Modification of extra physical education in public schools.
- Increased injury preventive awareness towards children with a high organized sports participating, inside and outside school.
- The present study gives updated knowledge of growth-related overuse injuries among young school-aged children.

References

1. Adirim TA, Cheng TL. Overview of injuries in the young athlete. *Sports Med.* 2003;33(1):75-81.
2. Axen I, Bodin L, Bergstrom G et al. The use of weekly text messaging over 6 months was a feasible method for monitoring the clinical course of low back pain in patients seeking chiropractic care. *J Clin Epidemiol*. 2012;65(4):454-61.
3. Bach LG, Eiberg S. *Aldersrelateret træning, Håndbog for 0. til 6. klasse*. 1 ed. Brøndby: Formegon ApS, DK; 2010, 114 p.
4. Baranowski T, Smith M, Baranowski J et al. Low validity of a seven-item fruit and vegetable food frequency questionnaire among third-grade students. *J Am Diet Assoc*. 1997;97(1):66-8.
5. Brenner JS. Overuse injuries, overtraining, and burnout in child and adolescent athletes. *Pediatrics*. 2007;119(6):1242-5.
6. Caine D, Caine C, Maffulli N. Incidence and distribution of pediatric sport-related injuries. *Clin J Sport Med*. 2006;16(6):500-13.
7. Caine D, DiFiori J, Maffulli N. Physeal injuries in children's and youth sports: reasons for concern? *Br J Sports Med*. 2006;40(9):749-60.
8. Caine DJ, Golightly YM. Osteoarthritis as an outcome of paediatric sport: an epidemiological perspective. *Br J Sports Med*. 2011;45(4):298-303.
9. Collard DC, Chinapaw MJ, Verhagen EA, Bakker I, van MW. Effectiveness of a school-based physical activity-related injury prevention program on risk behavior and neuromotor fitness a cluster randomized controlled trial. *Int.J.Behav.Nutr.Phys.Act.* 2010;7:9.

10. Craig P, Cooper C, Gunnell D et al. *Using natural experiments to evaluate population health interventions: guidance for producers and users of evidence*. Medical Research Counsil 2011. 29 p. Available from: Medical Research Counsil.
11. Dalton SE. Overuse injuries in adolescent athletes. *Sports Med*. 1992;13(1):58-70.
12. Dixon M, Fricker P. Injuries to elite gymnasts over 10 yr. *Med Sci Sports Exerc*. 1993;25(12):1322-9.
13. Emery CA, Meeuwisse WH, McAllister JR. Survey of sport participation and sport injury in Calgary and area high schools. *Clin J Sport Med*. 2006;16(1):20-6.
14. FIMS/WHO. Excessive physical training in children and adolescents. A position statement from the International Federation of Sports Medicine (FIMS). *Schweiz Z. Sportmed.* 1991;39(1):32-4.
15. Flynn JM, Lou JE, Ganley TJ. Prevention of sports injuries in children. *Curr Opin Pediatr*. 2002;14(6):719-22.
16. Garrick JG, Requa RK. Sports and fitness activities: the negative consequences. *J Am Acad Orthop Surg*. 2003;11(6):439-43.
17. Heath GW, Parra DC, Sarmiento OL et al. Evidence-based intervention in physical activity: lessons from around the world. *Lancet*. 2012;380(9838):272-81.
18. Herman K, Barton C, Malliaras P, Morrissey D. The effectiveness of neuromuscular warm-up strategies, that require no additional equipment, for preventing lower limb injuries during sports participation: a systematic review. *BMC Med*. 2012;10:75.
19. Johansen B, Wedderkopp N. Comparison between data obtained through real-time data capture by SMS and a retrospective telephone interview. *Chiropr Osteopat*. 2010;18:10.
20. Kannus P, Nittymaki S, Jarvinen M. Athletic overuse injuries in children. A 30-month prospective follow-up study at an outpatient sports clinic. *Clin Pediatr (Phila)*. 1988;27(7):333-7.
21. Kujala UM, Kettunen J, Paananen H et al. Knee osteoarthritis in former runners, soccer players, weight lifters, and shooters. *Arthritis and rheumatism*. 1995;38(4):539-46.
22. LaBella CR, Huxford MR, Grissom J, Kim KY, Peng J, Christoffel KK. Effect of neuromuscular warm-up on injuries in female soccer and basketball athletes in urban public high schools: cluster randomized controlled trial. *Arch Pediatr Adolesc Med*. 2011;165(11):1033-40.
23. Lachenbruch PA. Analysis of data with excess zeros. *Stat Methods Med Res*. 2002;11(4):297-302.
24. Long JS, Freese J. *Regression Models for Categorical Dependent Variables Using Stata*. 2nd. ed. Collage Station, Texas: Stata Press; 2006.
25. Maffulli N, Chan D, Aldridge MJ. Derangement of the articular surfaces of the elbow in young gymnasts. *J Pediatr Orthop*. 1992;12(3):344-50.
26. Medlar RC, Lyne ED. Sinding-Larsen-Johansson disease. Its etiology and natural history. *J Bone Joint Surg Am*. 1978;60(8):1113-6.
27. Micheli LJ, Fehlandt AF, Jr. Overuse injuries to tendons and apophyses in children and adolescents. *Clin Sports Med*. 1992;11(4):713-26.
28. New Agenda Solutions Web site: SMS-Track Questionnaire 2.1 [Internet]. Denmark; [cited 2013 Feb 1]. Available from: http://sms-track.com.
29. Ogden JA, Southwick WO. Osgood-Schlatter's disease and tibial tuberosity development. *Clin Orthop Relat Res*. 1976;(116):180-9.

30. Olsen OE, Myklebust G, Engebretsen L, Holme I, Bahr R. Exercises to prevent lower limb injuries in youth sports: cluster randomised controlled trial. *Bmj*. 2005;330(7489):449.
31. Pilgaard M. *Sport og motion i danskernes hverdag*. Copenhagen: Idrættens Analyseinstitut; 2009.
32. Pryce R, Willeberg S, Falkentoft C, Meyhoff T. *Aldersrelateret træning - Målrettet og forsvarlig træning af børn og unge*. Paritas Grafik A/S, Bõndby: Team Danmark; 2005.
33. Saperstein AL, Nicholas SJ. Pediatric and adolescent sports medicine. *Pediatr Clin North Am*. 1996;43(5):1013-33.
34. Team Denmark Web site [Internet]. Brøndby: Team Danmark; [cited 2012 May 7]. Available from: http://www.teamdanmark.dk/Fokusomrader/Elitekommuner/Artikler/Ydelser-Idraetsskoler.aspx.
35. Tveit M, Rosengren BE, Nilsson JK, Karlsson MK. Former Male Elite Athletes Have a Higher Prevalence of Osteoarthritis and Arthroplasty in the Hip and Knee Than Expected. *The American journal of sports medicine*. 2011.
36. Valovich McLeod TC, Decoster LC, Loud KJ et al. National Athletic Trainers' Association position statement: prevention of pediatric overuse injuries. *J Athl Train*. 2011;46(2):206-20.
37. Verhagen E, Collard D, Paw MC, van Mechelen W. A prospective cohort study on physical activity and sports-related injuries in 10-12-year-old children. *Br J Sports Med*. 2009;43(13):1031-5.
38. Vuong QH. Likelihood ratio tests for model selection and non-nested hypotheses. *Econometrica*. 1989;57(2):307-33.
39. Watkins J, Peabody P. Sports injuries in children and adolescents treated at a sports injury clinic. *J Sports Med Phys Fitness*. 1996;36(1):43-8.
40. Wedderkopp N, Jespersen E, Franz C et al. Study protocol. The Childhood Health, Activity, and Motor Performance School Study Denmark (The CHAMPS-study DK). *BMC Pediatr*. 2012;12(1):128.
41. World Health Organization: International Classification of Diseases [Internet]. [cited 2013 Feb 1]. Available from: http://www.who.int/classifications/icd/en/.

Paragraph 32:

Figure captions:

Figure 1 Injuries divided into subgroups: schools with extra PE (normal PE)

Figure 2 Weekly leisure time sports mean participation by school-type, presented over grade level at baseline. The children were followed for two years. Grade level is given as grade level at baseline August 2009.

Figure 3 Probabilities of experience injuries as weekly OSP varies from 0 to 5. The probabilities are the cumulated probabilities of experiencing one or more injuries and correspond to the negative binomial part of the zero-inflated negative binomial regression model. The vertical dashed line marks the overall mean participation in organized sports.

Figure 1 Injuries divided into subgroups

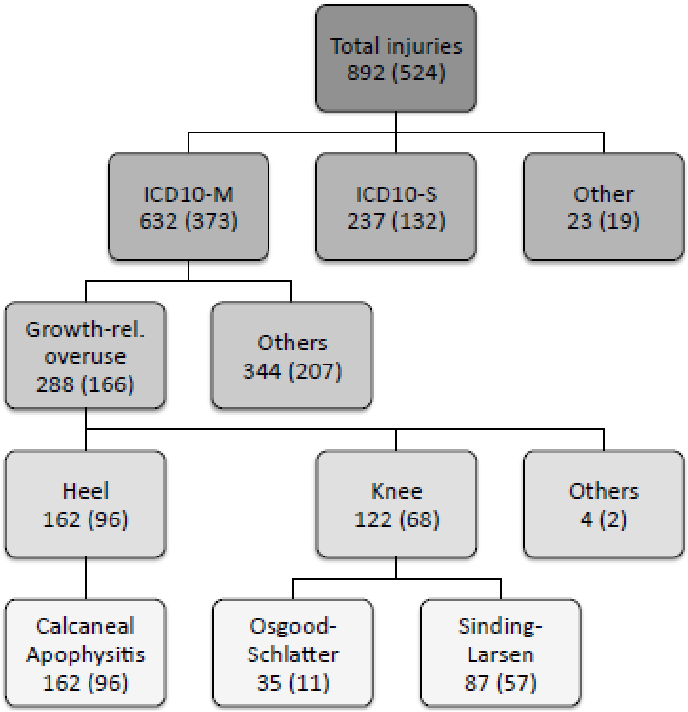

Table 1. Overview over data used in the analyses listed by school-type.

	Normal PE schools	Extra PE schools
Children (total N=1062)	443	619
Gender		
male	227	270
female	216	349
Age (Aug.2009)		
mean (SD)	9.3 (SD 1.46)	9.2 (SD 1.40)
range	6.5-12.2	6.2-12.4
Grade level Aug.2009 (N)		
1.	72	115
2.	91	126
3.	91	143
4.	90	123
5.	99	112
Injuries (ICD-10 count)		
children with 0 injuries	189 (43 %)	239 (39 %)
total count	524 (mean 1.2, SD 1.45)	892 (mean 1.4, SD 1.65)
total M-count	373 (mean 0.8, SD 1.16)	632 (mean 1.0, SD 1.36)
total GRO-count	166 (mean 0.4, SD 0.69)	288 (mean 0.5, SD 0.80)
total S-count	132 (mean 0.3, SD 0.60)	237 (mean 0.4, SD 0.52)
other ICD-10 (T, Q, Z)	19 (mean 0.04, SD 0.20)	23 (mean 0.04, SD 0.19)
OSP		
mean OSP/week (SD)	1.77 (SD 1.07)	1.44 (SD 0.96)
range	0-7.2	0-5.0
Weeks with SMS answer OSP		
mean (SD)	84.2 (SD 5.9)	84.4 (SD 5.6)
range	53-87	53-87

Figure 2

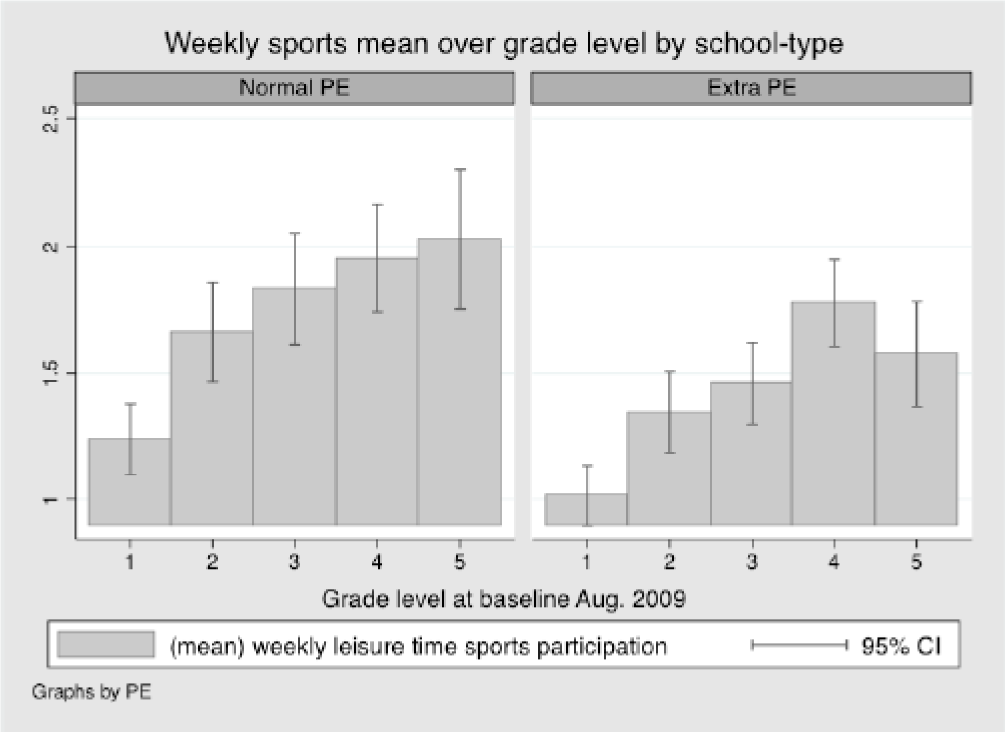

Figure 2 Weekly leisure time sports mean participation by school-type, presented over grade level at baseline. Since the children were followed for two years, grade level 1 correspons to grade level 1 and 2 and so on.

Fig 3 – GraphCombineGray14.png

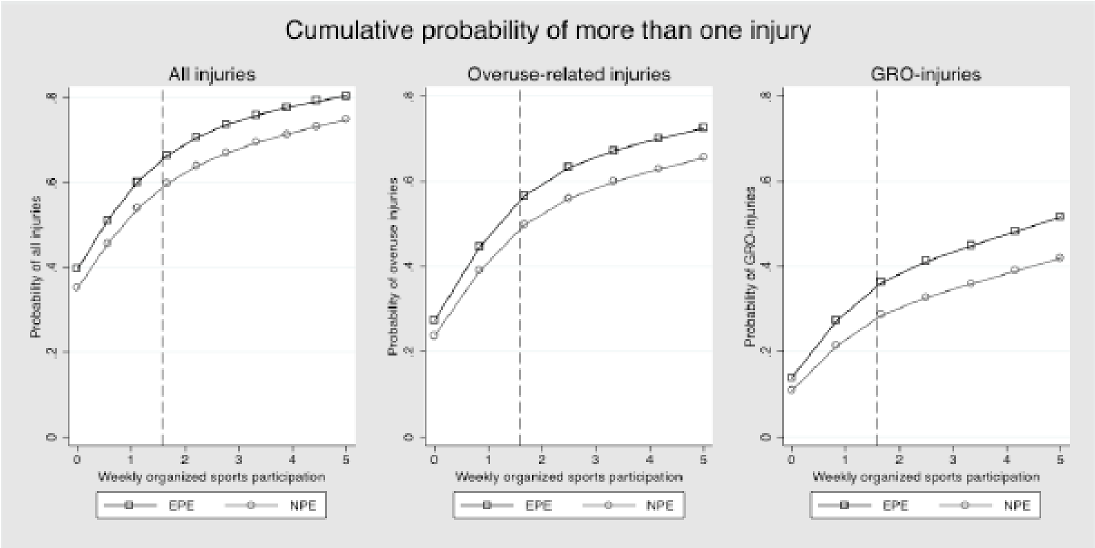

Fig. 3: Probabilities of experience injuries as weekly OSP varies from 0 to 5. The probabilities are the cumulated probabilities of experiencing one or more injuries and correspons to the negative binomial part of the zero-inflated negative binomial regression model. The vertical dashed line marks the overall mean participation in organized sports.

Table 2. The variables, coefficients, robust standard error (adjusted for clustering at class level), P-values, confidence intervals and exponential values of the coefficients and standard derivations from a zero inflated negative binomial regression model of the total-, overuse- and growth-related overuse injury count.
Exp(b) = factor change in expected odds (logit) or count (neg.binomial) for unit increase in X.

Binary equation – injury or not (logistic part):
Factor change in odds of no injuries – all subjects

X	Coefficient	Robust SE	z	P>|z|	95% CI	Exp(b)	SD of X
Sports mean	-1.247	0.358	-3.48	0.000	-1.95-(-0.55)	0.29	1.02
Intercept	-0.361	0.341	-1.06	0.290	-1.03-(-0.31)		

Count equation – number of injuries (negative binomial part):
Factor change in expected count for subjects with more than zero injury

X	Coefficient	Robust SE	z	P>|z|	95% CI	Exp(b)	SD of X
PE	0.254	0.096	2.65	0.008	0.07-0.44	1.29	0.49
Sports mean	0.108	0.046	2.35	0.019	0.02-0.20	1.11	1.02
Gender	0.199	0.078	2.56	0.010	0.05-0.35	1.10	0.50
Intercept	-0.019	0.154	-0.13	0.900	-0.32-0.28		

Binary equation – overuse injury or not (logistic part):
Factor change in odds of no injuries – all subjects

X	Coefficient	Robust SE	z	P>|z|	95% CI	Exp(b)	SD of X
Sports mean	-1.356	0.317	-4.27	0.000	-1.98-(-0.73)	0.26	1.02
Intercept	0.120	0.349	0.73	0.732	-0.56-0.80		

Count equation – number of overuse injuries (negative binomial part):
Factor change in expected count for subjects with more than zero injury

X	Coefficient	Robust SE	z	P>|z|	95% CI	Exp(b)	SD of X
PE	0.253	0.097	2.60	0.009	0.06-0.44	1.29	0.49
Sports mean	0.100	0.049	2.01	0.044	0.00-0.20	1.10	1.02
Gender	0.205	0.093	2.21	0.027	0.02-0.39	1.23	0.50
Intercept	-0.303	0.170	-1.78	0.075	-0.64-0.03		

Binary equation – growth-related overuse injury or not (logistic part): *Factor change in odds of no injuries – all subjects*							
X	Coefficient	Robust SE	z	P>|z|	95% CI	Exp(b)	SD of X
Sports mean	-1.770	0.573	-3.09	0.002	-2.89-(-0.65)	0.17	1.02
Intercept	0.325	0.573	0.57	0.570	-0.80-1.45		
Count equation – number of growth-related overuse injuries (negative binomial part): *Factor change in expected count for subjects with more than zero injury*							
X	Coefficient	Robust SE	z	P>|z|	95% CI	Exp(b)	SD of X
PE	0.319	0.136	2.34	0.019	0.05-0.59	1.38	0.49
Sports mean	0.130	0.067	1.95	0.051	-0.00-0.26	1.14	1.02
Grade level							
1st	baseline	-	-	-	-	-	-
2nd	0.609	0.233	2.61	0.009	0.15-1.07	1.28	0.40
3rd	0.614	0.224	2.74	0.006	0.17-1.05	1.29	0.41
4th	0.764	0.231	3.30	0.001	0.31-1.22	1.36	0.40
5th	0.575	0.215	2.68	0.007	0.15-1.00	1.26	0.40
Intercept	-1.686	0.270	-6.25	0.000	-2.21-(-1.16)		