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SPORTS & EXERCISE | RESEARCH ARTICLE

Adolescent physical activity-related injuries in sports club, school sports and other leisure time physical activities

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Abstract: *Background:* The objective was to study physical activity (PA)-related injuries in sports club, school sports, and other leisure time PA, and the associations between injuries and PA participation frequency and intensity. *Methods:* A nationally representative sample was obtained and a structured questionnaire was sent. A total of 9,462 Finns (12–18 years) completed the survey. Prevalence of PA-related injuries was gathered by separate questions about sports club injuries, school sports injuries and other leisure time PA injuries. *Results:* Injury prevalence was higher in sports club activities than in other leisure time PA or school sports for boys ($p < 0.001$) and girls ($p < 0.001$). The prevalence of other leisure time injuries was higher than the prevalence of injuries in school sports for boys ($p < 0.001$) and girls ($p < 0.001$). Injuries were associated with higher frequency (OR 10.4, 95% CI 6.7–16.3) and intensity (OR 4.1, 95% CI 2.9–5.8) of PA. *Conclusions:* Out of the three settings, injury prevalence was highest in sports club activities. Higher PA participation frequency and intensity increased the risk of injury. There seems to be a need for further preventative measures to reduce the risks of PA-related injuries, especially in the sports club setting.

Subjects: Physical Education; Youth Sport; Health Promotion; Sports Injury; Quantitative Methods in Sport; Children and Youth

Keywords: adolescent; athletic injuries; exercise; injuries; physical activity

ABOUT THE AUTHORS

This study is part of the Adolescent Health and Lifestyle Survey (AHLS). The AHLS is a nationwide survey system monitoring the health and health-related lifestyle of young people in Finland. The survey has been conducted every second year since 1977. Professor Arja Rimpelä has been the principal investigator of AHLS nearly 30 years. Physical activity has been part of the subjects since very beginning while injuries related to physical activity is a new subject, led by adjunct professor Jari Parkkari. The principal author Anu Räisänen prepares her doctoral thesis on physical activity related injuries and their prevention among adolescents.

PUBLIC INTEREST STATEMENT

Participation in physical activity (PA) provides positive effects on health and wellbeing. The downside of PA is the risk of injury. Adolescents are active in different setting: in sports clubs, schools, and in unorganised activities during leisure time. In sports clubs the proportion of adolescents who get injured is higher than in other settings. But on the other hand, other leisure time PA is more widely practiced. This leads to a high number of injuries even though the proportion of injured adolescents is lower than in sports clubs.

Higher frequency and higher intensity of PA is associated with a higher risk of injuries. There is an urgent need to introduce proven injury prevention measures, such as neuromuscular training, safe equipment and environment in different PA settings.

1. Introduction

Physical activity (PA) in adolescence is associated with various positive outcomes on health, wellbeing, and socio-economic factors. Adolescent PA provides health benefits such as improved bone health (Hallal, Victora, Azevedo, & Wells, 2006), lower blood pressure (Janssen & LeBlanc, 2010), positive changes on the markers of metabolic syndrome (Janssen & LeBlanc, 2010), and lower odds of overweight and obesity (Janssen, Katzmarzyk, Boyce, King, & Pickett, 2004). Adolescent PA also promotes self-esteem (Biddle & Asare, 2011; Hallal et al., 2006) and mental health (Biddle & Asare, 2011). In addition to the positive health effects, PA participation in adolescence predicts higher educational level, higher socio-economic status and higher earnings in adulthood (Kari et al., 2016; Koivusilta, Nupponen, & Rimpelä, 2011). Other important benefits of PA participation are relaxation (van Mechelen et al., 1996), fun, enjoyment, social support, social interaction (Allender, Cowburn, & Foster, 2006) it provides.

Even though sports and recreational activities are generally safe and promote good health, it has been recognized that PA-related injuries have a significant impact on public health (Finch, Wong Shee, & Clapperton, 2014; Schwebel & Brezaussek, 2014). The incidence of PA-related injuries is higher among adolescents than adults (Schmikli, Backx, Kemler, & van Mechelen, 2009), and in the past decades, injury occurrence among young people has increased (Tiirikainen, Lounamaa, Paavola, Kumpula, & Parkkari, 2008). Participation in sports and recreational activities has been identified as a major cause of adolescent injuries (Pickett et al., 2005). In Finland, adolescent sports club participation is the strongest risk factor for injury hospitalization throughout adolescence and early adulthood (Mattila, Parkkari, Koivusilta, Kannus, & Rimpelä, 2009). PA-related injuries also have long term consequences since they can lead to sub-optimal health in later life (Drawer & Fuller, 2001; Kujala, Kaprio, & Sarno, 1994).

Injuries have been reported to be the leading cause why people stop participating in PA (National Center for Disease Control & Prevention, 2002). It has been estimated that annually 8% of adolescents drop out of recreational sporting activities because of injuries or the fear of getting injured (Grimmer, Jones, & Williams, 2000). Reducing the risk of injury increases the likelihood of the continued health benefit (MacKay et al., 2004).

The first step in the sequence of prevention of PA-related injuries is establishing the extent of the injury problem (van Mechelen, Hlobil, & Kemper, 1992). Studies on adolescent PA-related injuries often focus on the individuals who participate in sports in the elite level, while relatively little is known about the injuries that occur in other PA settings. Some prior studies have investigated PA-related injuries in different settings among 6–12-year-old children (Bloemers et al., 2012; Jespersen et al., 2015; Verhagen, Collard, Paw, & van Mechelen, 2009), but we are not aware of previous studies on sports club, school sports and leisure time PA-related injuries on adolescent populations.

In sports club the activities are usually structured and often the focus is on improving the performance in a single sport. In this study school sports cover both the mandatory and self-selected physical education classes (these are mandatory in Finland) and possible student sport activities organised by the school, for example ball games organised during the recess or after school. Other leisure time PA consists of unorganised physical activities, which in Finland can vary by the season, since winter offers very different opportunities for PA summer.

The main objective of this study was to compare the injury rates of 12–18-year-olds in three settings: sports club, school sports and leisure time physical activities. The second aim was to study the association between age and injury prevalence in different settings. Thirdly this study set out to investigate the association between PA-related injuries and PA-participation frequency and exercise intensity. Based on previous studies on younger populations, we hypothesized that there would be more injuries in sports clubs than in other PA settings.

2. Materials and methods

2.1. Data collection

This study is part of the Adolescent Health and Lifestyle Survey (AHLS). The AHLS is a nationwide survey system monitoring the health and health-related lifestyle of young people in Finland. The survey has been conducted every second year since 1977. The survey covers several topics related to adolescent health. Some of the topics alternate and the questions about PA-related injuries were included in the survey in 2009 and 2013. This study reports the combined data from those two years.

In each study year, a nationally representative sample of 12, 14, 16, and 18-year-old Finns born on certain days in June, July, and August was obtained from the Population Register Centre. The dates of birth used in the sampling were selected to ensure the sample included different subjects for each study year. A 12 page structured questionnaire was mailed in February of both study years. Enclosed with the questionnaire the subjects received personal user names and passwords, and information about the option of completing the questionnaire online. Up to three follow-up enquiries were sent to non-respondents. The questionnaire was sent to a total of 19,318 subjects: 9,920 subjects in 2009 and 9,398 subjects in 2013.

2.2. Study participants

In 2009 the number of respondents was 5,516, out of which 2,288 were boys and 3,228 were girls. In 2013, 4,158 responded (1,687 boys and 2,471 girls). For the combined data of 2009 and 2013, the response rate was 50%. A total of 212 subjects were excluded from the analysis due to inconsistencies between their injury information and their PA participation information or information about their student status. In these cases the subject reported no PA participation or being a student but reported an injury in that setting, or vice versa. Out of the 9,462 subjects included in the study, 59% were girls and 41% were boys. The distributions for age groups for boys and girls are presented in Table 1. Participation rates in sports club activities, school sports, and other leisure time PA are presented in Table 2.

2.3. Measurements

2.3.1. PA-related injuries

The injury prevalence refers to the proportion of subjects who had been injured in physical activities during the past twelve months. The injury prevalence's in three settings were based on three questions: "During the past year, have you suffered an injury while participating in sports club activities?", "During the past year have you suffered an injury while participating in a physical education class or instructed student sport?", and "During the past year have you suffered an injury while participating in other leisure time physical activities (not in a sports club)?" In 2009, three options were provided: "No", "Once", and "Twice or more". In 2013, there were four options: "No", "Once", "Twice", and "Three times or more". Due to the different answer options in 2009 and 2013, the injury data were combined to create a dichotomous variable consisting of classes "Not injured" and "Injured at least once". Information about student status was inquired with the question "At the moment, are you a student?" Three options were provided: "No, I'm not a student", "Yes, I am a full time student", and "Yes, I'm a student alongside going to work". In the Finnish education system, physical education is mandatory in comprehensive schools, general upper secondary schools, and vocational schools.

Table 1. Proportions of subjects in age groups by gender

Age (years)	Boys (n = 3,881)		Girls (n = 5,581)	
	%	95% CI	%	95% CI
12	16.5	15.3–17.7	12.4	9.9–14.9
14	30.7	29.2–32.2	29.8	28.6–31.0
16	30.2	28.8–31.6	29.2	28.0–30.4
18	22.6	21.3–23.9	28.6	27.4–29.8

Note: CI = confidence interval.

Table 2. Proportions of subjects participating in sports club activities, school sports and other leisure time physical activities by gender

Physical activity setting	Boys (<i>n</i> = 3,881)		Girls (<i>n</i> = 5,581)	
	%	95% CI	%	95% CI
Sports club activities	52.5	50.8–54.2	47.7	46.3–49.1
School sports	97.2	96.7–97.7	97.4	97.0–97.8
Leisure time PA	95.6	94.9–96.3	97.1	96.6–97.6

Note: CI = confidence interval.

Based on this, it was assumed that all the subjects, who reported being students, participate in school sports (physical education classes and student sports).

The injury prevalence in sports club activities was calculated as a percentage of subjects reporting at least one sports club injury out of subjects reporting participation in sports club activities. The injury prevalence in school sports activities was calculated as a percentage of subjects reporting at least one school sports injury out of subjects reporting being students. The injury prevalence in other leisure time PA was calculated as a percentage of subjects reporting at least one leisure time PA injury out of subjects reporting participation in other leisure time PA.

2.3.2. PA participation and exercise intensity

PA participation levels were derived from two questions: “How often do you participate in sports in your leisure time through sports club training, competitions or games?” and “How often do you participate in PA in other ways in your leisure time?” Seven alternatives were provided: “not at all”, “less often than once a month”, “1–2 times a month”, “approximately once a week”, “2–3 times a week”, “4–5 times a week”, and “approximately every day”. Exercise intensity was determined from the question “When I do sports or PA, usually I experience: no sweating or getting out of breath/some sweating or getting out of breath/moderate sweating or getting out of breath/extensive sweating or getting out of breath/I do not exercise in my leisure time”.

To determine whether exercise intensity was related to injuries, the injuries in sports club, school sports, and other leisure time PA were combined into a new dichotomous variable: “Suffered at least one PA-related injury”. The injury prevalence was calculated as the proportion of subjects reporting at least one injury out of all the subjects.

2.4. Ethics

The study follows the ethical principles of the Declaration of Helsinki. Subjects were informed of the aims, methods, voluntary participation, privacy and confidentiality of the collected information. The study protocol has been approved by the Ethics Committee of Tampere Region (reference Lausunto 2/2010) and the Ethics Committee of the Pirkanmaa Hospital District (reference ETLR06226). Written informed consent was not required.

2.5. Statistical methods

Statistical analyses were performed using the SPSS software (IBM SPSS Statistics Version 23 for Windows). Since some subjects had been injured in more than one PA setting, the groups were not considered to be independent when comparing the injury prevalence between the sports club activities, school sport activities, and other leisure time PA. Therefore McNemar’s test for two related samples was used to test the differences in injury prevalence between PA settings. Pearson’s χ^2 test was used to test differences in the injury prevalence between age groups. Odds ratios (ORs) were used to test for differences in the injury prevalence by sport club participation frequency, other leisure time PA participation frequency and exercise intensity. ORs were obtained from multivariate logistic regression analysis. Age and gender were entered into each multivariate model to adjust for their potential confounding effect. A *p*-value of <0.05 was considered statistically significant.

3. Results

3.1. Injury prevalence in different settings

Out of the subjects who reported participating in PA in any of the three settings, 32.0% (95% CI, 31.0–33.0) had suffered at least one PA-related injury in the past 12 months. The injury prevalence in sports club activities was 27.5% (95% CI, 25.4–29.6) for boys and 23.8% (95% CI, 22.0–25.6) for girls. In school sports activities, the injury prevalence was 9.8% (95% CI, 8.8–10.8) for boys and 10.0% (95% CI, 9.2–10.8) for girls. In other leisure time PA, the injury prevalence was 17.6% (95% CI, 16.3–18.9) for boys and 13.3% (95% CI, 12.3–14.3) for girls.

According to the McNemar's test for two related samples, the injury prevalence in sports club activities was significantly higher than the injury prevalence in school sports and in other leisure time PA for boys ($p < 0.001$) and girls ($p < 0.001$). The prevalence of other leisure time PA injuries was higher than the prevalence of school sport injuries for boys ($p < 0.001$) and girls ($p < 0.001$).

Pearson's χ^2 test was used to test for differences between age groups. The injury prevalence in sports club, school sports and other leisure time PA by age groups are shown in Figure 1. The injury prevalence varied significantly between the age groups in sports club injuries for boys ($p < 0.05$) and girls ($p < 0.05$). The sports club injury prevalence was highest in the 16 and 18-year-olds among boys

Figure 1. Injury prevalence (%) in sports club activities, school sports and other leisure time physical activities in the past 12 months by age group for boys and girls presented with 95% confidence interval (CI).

Notes: Proportions were calculated from those reporting participation in sports club activities/being students/participation in other leisure time PA. Pearson's χ^2 test was used to test for differences between age groups.

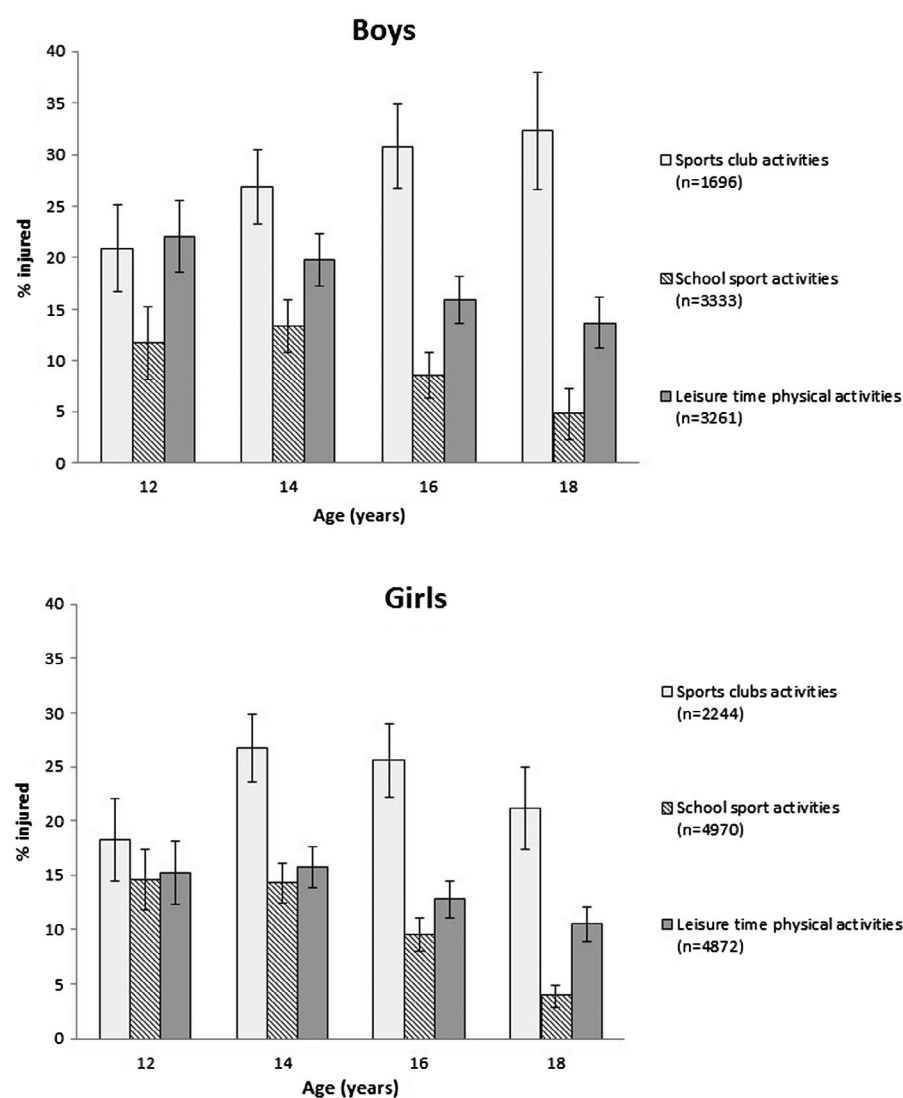


Table 3. Age and gender-adjusted ORs and 95% CIs for sports club injuries by frequency of sports club activity

Frequency of sports club activity	OR	95% CI	<i>p</i> -value
Less than once a month	1		
1–2 Times a month	1.8	1.0–3.1	0.041*
Approximately once/week	1.5	0.9–2.3	0.103
2–3 Times/week	3.1	2.0–4.6	<0.001*
4–5 Times/week	6.9	4.5–10.5	<0.001*
Approximately daily	10.4	6.7–16.3	<0.001*

Note: ORs were derived from multivariate logistic regression analysis.

*Statistical significance based on $p < 0.05$.

and in the 14-year-olds among girls. In school sports and other leisure time PA, the injury prevalence was lowest in the older age groups among boys ($p < 0.001$) and girls ($p < 0.001$).

3.2. Associations between injuries and PA participation and intensity

Multivariate logistic regression analysis was used to test for the associations between injuries and PA participation and intensity. Sports club injuries were associated with the frequency of sports club activities. The odds ratio was highest for those who participated in sports club activities approximately every day (OR 10.4, 95% CI 6.7–16.3). Participating in sports club activities 2–3 times per week or more often significantly increased the risk of sports club injury. The ORs for sports club injuries by participation frequency are presented in Table 3.

The risk for other leisure time PA injuries increased when participation frequency was once a week or higher. The ORs for other leisure time injuries by participation frequency are presented in Table 4.

Table 4. Age and gender-adjusted ORs and 95% CIs for other leisure time injuries by frequency of leisure time physical activity (PA)

Frequency of other leisure time PA	OR	95% CI	<i>p</i> -value
Less than once a month	1		
1–2 Times a month	1.3	0.8–2.2	0.232
Approximately once/week	1.7	1.1–2.6	0.013*
2–3 Times/week	2.1	1.4–3.1	0.001*
4–5 Times/week	2.6	1.7–3.9	<0.001*
Approximately daily	3.1	2.0–4.7	<0.001*

Note: ORs were derived from multivariate logistic regression analysis.

*Statistical significance based on $p < 0.05$.

Table 5. Age and gender-adjusted ORs and 95% CIs for all physical activity-related injuries by intensity of physical activity

Intensity (sweating/getting out of breath)	OR	95% CI	<i>p</i> -value
None	1		
Some	1.6	1.1–2.3	0.009*
Moderate	2.2	1.6–3.2	<0.001*
Extensive	4.1	2.9–5.8	<0.001*

Note: ORs were derived from multivariate logistic regression analysis.

*Statistical significance based on $p < 0.05$.

Exercise intensity was associated with the risk of PA-related injury. Those reporting moderate or extensive sweating/getting out of breath when exercising had 4.1 times higher risk of injury compared to those, who didn't sweat/get out of breath when exercising. The ORs for all PA-related injuries by intensity level are presented in Table 5.

4. Discussion

To our knowledge, this is the first study to compare the injury prevalence in sports club activities, schools sports and other leisure time PA among adolescents. The findings of this study demonstrate that the injury prevalence was significantly higher in sports club activities than in school sports activities and other leisure time PA. In addition, the prevalence of other leisure time PA injuries was higher than the prevalence of school sport injuries. One possible explanation to these differences could be the intensity of PA, since our results also show that exercise intensity was associated with the risk of injury. The sports club PA is structured and the goal is to improve sports performance, therefore it is possibly more intense than other leisure time PA. In school sports the goal is mainly educational and the intensity is likely to be lower than in the other PA settings.

Previous studies on injuries in sports clubs, school sports and other leisure time injuries have been done on school children, aged 12 years and under. Jespersen et al. (2015) studied musculoskeletal injuries among 6–12-year-old Danish school children. They reported the highest rate of traumatic injuries in sports (1.57 injuries/1,000 PA units), followed by leisure time PA (0.57 injuries/1,000 PA units) and PE lessons (0.14 injuries/1,000 PA units). In the iPlay study Verhagen et al. (2009) studied injuries among 10–12 years old Dutch children. The injury incidence density was highest in sports (0.66), followed by PE (0.50) and leisure time PA (0.39). The differences between settings were not significant. Besides these studies focusing on children, direct comparisons are difficult to make due to differences in injury definitions and data collection methods. The common trend in the results of this study and the work of Jespersen et al. (2015) and Verhagen et al. (2009) is that in all the three studies, the prevalence of injuries is highest among sports club activities. Therefore it can be suggested that preventative measures should be introduced more extensively to sports club activities, especially to the sports popular among adolescents.

Among boys the prevalence of sports club injuries increased with age. It has been previously reported that in adolescent sports the intensity and training load increase progressively with age (Malisoux, Frisch, Urhausen, Seil, & Theisen, 2013b). Intensity being associated with the risk of injury, the increase in intensity could explain the increase in boys' injury prevalence. Previous studies suggest that the relation between injuries and age is sport-specific. In a soccer injury study the 16- and 18-year-old boys had lower injury incidence than the 14-year-olds (Emery, Meeuwisse, & Hartmann, 2005). In a hockey injury study the injury incidence increased significantly with age (Emery & Meeuwisse, 2006). In the current study the prevalence of sports club injuries among girls was highest in the 14-year-olds. This is in line with the results of Emery et al. (2005) reporting a higher incidence of soccer injuries among the 14-year-olds than the 16 and 18-year-olds. Sport is one possible factor contributing to the differences in injury prevalence between age groups in this study.

In this study, risk of PA-related injuries increased when the frequency of PA increased. The increase of risk was highest in sports club injuries, where those participating approximately daily had 10.4 times higher risk of injury than those participating less than once a month. This high increase in the risk is somewhat surprising, since there is evidence that training has a protective effect against injury (Gabbett, 2016). In sports, both overtraining and under-training could be linked with a high incidence of injuries (Gabbett, 2016). Under-training is possibly associated with injuries in other PA settings also. In the iPlay-study, Bloemers et al. (2012) studied injuries in leisure time PA, sports and physical education classes in 10–12-year-old children. They demonstrated that the least active children had the highest risk of injury and identified the cut-off level to be 5 h of PA per week. The results of the current study do not support the theory that low levels of participation or under-training increase the risk of injury. It is important to bear in mind that in this study the frequency of sports club activities and other leisure time PA were analysed separately and this could yield different results than using weekly total exposure.

In this study intensity was defined as the level of sweating/getting out of breath during exercise. Sweating and getting out of breath are recommended for adolescents since they need both moderate and vigorous exercise (World Health Organization, 2010). Participating in intense exercise should not be limited by the fear of injury. One possible approach to lowering the risk of injury in intense exercise is developing better movement skills. Neuromuscular training programs aimed to improve movement skills have produced lower injury rates in high intensity sports among adolescent populations (Hägglund, Atroshi, Wagner, & Waldén, 2013; Rössler et al., 2014; Soligard et al., 2008; Wedderkopp, Kalltoft, Lundgaard, Rosendahl, & Froberg, 1999). School-based injury prevention program consisting of neuromuscular training has also been used successfully to reduce the injury risk and at the same time to improve health factors like adiposity and fitness (Richmond, Kang, Doyle-Baker, Nettel-Aguirre, & Emery, 2016). In organized settings, such as sports clubs, another method to lower the injury incidence is implementing an injury surveillance system. Implementing a surveillance system can improve awareness of the problem and further motivate coaching staff to implement preventative measures (Malisoux, Frisch, Urhausen, Seil, & Theisen, 2013a).

In the Finnish education system, physical education classes are mandatory in comprehensive schools, general upper secondary schools, and vocational schools. In this study, the injury prevalence was lower in school sports activities than in other PA settings. However, it could be argued that when participation is mandatory and the goal is educational, the risk of injury should be as low as possible. This result could indicate that further preventative measures should be implemented to lower the injury risk in school sports activities.

The coaches in the sport club activities and the teachers in school sports possess an important role in injury prevention. The coaches, support staff and teachers must enforce rules and the use of safety equipment, such as helmets and protective eye wear when applicable. They must also assess the environmental factors, like weather conditions, and evaluate of the conditions in which equipment are used, such as the apparatus in gymnastics. In addition to these factors load needs to be considered. In sports club coaches should monitor the load individually and make adjustments to training and competition loads if necessary (Soligard et al., 2016). In school sports the teachers should consider that the students most active in physical education lessons are usually active also in sports clubs, other leisure time PA (Trifonov Rexen et al., 2014). Children with low habitual levels of PA are at an increased risk of injury (Nauta, Martin-Diener, Martin, van Mechelen, & Verhagen, 2015). Mandatory physical education classes can be the only form of PA for these children. The teacher has a responsibility to keep the lessons safe for all children and insure that the load is manageable for everyone.

The large, randomly drawn sample can be considered a strength of this study. The response rate to this study was 50%. It has been reported that in survey studies the non-respondents have poorer health behaviour, health and socio-economic background (Pietilä, Rantakallio, & Läärä, 1995). The aim of this study was to compare injury rates in different PA settings in girls and boys of different age groups. Physically active adolescents were expected to respond at a higher rate, and thus, the total response rate was not considered to have a major impact on the reported comparisons.

This study has some limitations. Retrospective, self-reported injury history has the potential for recall bias. However, Gabbe, Finch, Bennell, and Wajswelner (2003) reported that participants were able to correctly indicate whether they had been injured or uninjured in the past 12 months. To minimize the impact of recall bias on the results, we only asked for the injury status and did not request more details, such as the number of injuries, the injured body region, the injury type, the severity or the diagnosis.

In the survey the word "injury" was not defined. It was up to the subject how they perceived the word. Since the purpose of this study was to compare the injury rates in different settings, we believe the lack of detailed injury definition was not necessary, since the subject probably defined injuries similarly in the different settings. It is possible that some minor injuries and overuse injuries have not been reported, and thus, the reported injury rates might slightly underestimate the situation. This is a possible limitation of the study.

Since physical education is mandatory, we interpreted that all subjects reporting to be students participated in schools sports. Since the students' in general upper secondary schools and vocational schools have some freedom to choose when they participate in physical education classes, it is possible that all the 18-year-old students had not participated in PE during the past 12 months. Hence the rate of school sport injuries might be slightly underestimated. This can be seen as a limitation of the study.

According to the "sequence of prevention" the next should be establishing aetiology and mechanisms of injuries (van Mechelen et al., 1992). Therefore in the future it would be beneficial to study in which sports and physical activities the injuries occur. This would provide further information for those working on implementing injury prevention methods. To evaluate the effectiveness of implementation measures and programmes, we recommend regular monitoring of injury prevalence among adolescent population.

5. Conclusions

This study suggests that the rate of PA-related injuries is higher in sports club activities than in other settings of PA among adolescents. Since injury in adolescence can have implications for future participation in PA and also for future health, it is important to introduce preventative measures more extensively, most urgently to the sports club setting. Some caution should be used when interpreting these results since this study is based on self-reported injuries.

This study also suggests that injury rates are associated with PA participation frequency and intensity. It is recommended for health benefits that adolescents participate in PA daily. However our results indicate that participating in PA as little as 2–3 times a week increases the risk of PA-related injury. Since PA participation generates several benefits for health and wellbeing, adolescent PA participation should not be limited due to fear of injury. Instead, the results of this research support the idea that further preventative measures are needed to lower the risk of injury in different settings. To evaluate the effect of preventative measures, it is important to monitor adolescent PA-related injury prevalence and injury settings in regular basis. In the future, it is important to follow PA-related injuries regularly so that a potential increase in injuries can be revealed and preventive measures can be started.

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Competing Interests

The authors declare no competing interests.

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Authors' contributions

Arja Rimpelä and Jari Parkkari initiated the study. Anu M. Räsänen, Jari Parkkari, Lotta Karhola, and Arja Rimpelä contributed to the study conception and design. Anu M. Räsänen carried out the literature search. Arja Rimpelä conducted the data collection and performed the preliminary data preparations. Anu M. Räsänen and Lotta Karhola conducted the data analyses, and all the authors contributed to the interpretation of data. Anu M. Räsänen,

Jari Parkkari and Arja Rimpelä wrote the first draft of the paper, and all authors provided substantive feedback on the paper and contributed to the final manuscript. All authors have approved the submitted version of the manuscript. Anu M. Räsänen is the guarantor.

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