



A PROSPECTIVE COHORT STUDY ON INJURIES AMONG INTENSIVELY PHYSICALLY ACTIVE HIGH SCHOOL STUDENTS

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ABSTRACT

BACKGROUND: The leading cause of non-fatal injuries in age group 14-19 is sports injuries. Purpose of the study was to determine the association between intense physical activity and injury and to identify the circumstances and environment in which injuries are most likely to occur.

METHODS: A prospective cohort study included 698 high school students 15-19 years old, divided into those exposed and those unexposed to intense physical activity. The international standard questionnaire about physical activity (IPAQ) and the metabolic equivalent task score (MET) were used.

RESULTS: The risk of injuries was seven times higher (RR: 7.041; 95% CI: 6.071, 8.187) and the risk of injuries requiring treatment in health facilities was 15 times higher (RR: 14,717; 95% CI: 10,652; 20,592) in the intensely physically active adolescents. The risk of gaining sports injuries was 11 times higher in the exposed group (RR: 11,212; 95% CI: 9,013; 14,074), with a significantly higher incidence rate among men (82.9 per 100). Most injuries occurred in football (Inc. 4.4 per 1000h), volleyball (Inc. 3.9 per 1000h) and boxing/kickboxing (Inc. 3.7 per 1000 h).

CONCLUSIONS: Intensely physically active high school students have a much higher risk of injury, which usually occurs during training or a match.

Keywords: adolescents; athletic injuries; physical activity; risk behaviours; youth sport; cohort studies.

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3 Individuals within the age group 15-19 years are more vulnerable to injury than other young
4 people¹⁻³. Although it is unquestionably proven that regular moderate physical activity has a
5 beneficial effect on the health of adolescents, the leading cause of non-fatal injuries in this age
6 group are sports injuries⁴. The intensity of physical activity is particularly relevant for estimation
7 of the optimal dose of physical activity, because the intensity is the major contributor to medical
8 complications caused by exercise⁵⁻⁶. Results of several studies suggest that when evaluating the
9 dose-response, potential risks for the target population should also be taken into consideration,
10 not just the dose that induces the greatest health benefits. The more intense the exercises and
11 greater the dose of physical activity, the more frequent are the health risks. In recent years, an
12 increasing number of young people has been involved in intense training, with high levels of
13 competitive activity from an early age, increasing the exposure to injuries⁷. Although most
14 injuries associated with sports and recreational activities are not life-threatening, nonetheless
15 they cause direct pain and suffering, and short-term or long-term incapacity. Also, the
16 consequences, such as abandonment of further sports activity and disability, are more serious
17 with high direct and indirect healthcare and social costs⁸. Withdrawal from further physical
18 activity is a particular public health problem, due to the long-term health consequences of
19 absence of physical activity in adulthood⁹⁻¹¹.

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22 The purpose of the study was to find the relationship between intense physical activity and injury
23 in a high school cohort and to report how the risk factors for injuries are related to the behaviour
24 and the environment in which the physical activity related injury was most likely to occur.
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METHODS

A prospective cohort study among the high school students age 15-19 was conducted for 12 months during 2012 and 2013.

Setting

Five high schools in XXX [Blinded by request from JSH] , or 45% of high school in XXX [Blinded by request from JSH]. A stratified random sample was used, and the strata were determined in the way to provide the territorial representation of the area and type of high schools (professional orientation, age of students). Selection of classes within each school was conducted by the method of random numbers.

Participants

The sample included 700 respondents from five secondary schools (gymnasium, medical, economic, technical and chemical-technological school). The sample represents 11% of high school students in XXX [Blinded by request from JSH]. The total sample consisted of 41% male, 59% female students.

Instruments

This preselection process was carried out by the short form of the international standardized questionnaire about physical activity (International Physical Activity Questionnaire - IPAQ - Short Form, rev. version 2005)^{12,13}. The questionnaire provides separate scores for each type of activity: intense, moderate and easy. The assessment was carried out through engagement in four domains: a) light exercise/walk; b) moderate physical activity; c) intense physical activity, d) the

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3 time spent at rest (sitting/lying down). The questions were focused on the time a person spent
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5 doing physical activity and rest during the previous seven days.
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8 All injuries that happened during the 12 month study period were registered through a structured
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10 questionnaire, modified for research purposes (Adolescent Injury Checklist-AIC), completed by
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12 students¹⁴. Injuries that did not require medical aid were also included. The questionnaire on
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14 injuries had five domains: Socio-demographic characteristics of the respondents; Habits and
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16 behaviour; Physical activity and health; Injuries (type, method and place of origin); Method and
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18 the consequences of violence.
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21 Both questionnaires were translated, pilot tested locally and validated.
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24 25 26 **Procedure**

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28 The students were assigned to the group of those exposed and to the group not exposed to
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30 physical activity, based on a preselection process.
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33 Quantifying the level of physical activity was performed by the calculation of metabolic
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35 equivalent task (MET). Each type of activity and the required energy was weighted and defined
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37 in MET, in order to obtain the result in MET-minutes. Calculation of the total MET score was
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39 performed by summing the duration (in minutes) and frequency (in days) of all three types of
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41 physical activity during the previous seven days. Respondents were classified into three
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43 categories according to the total volume of physical activity, based on the Guidelines for Data
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45 Processing and Analysis of the International Physical Activity Questionnaire: a.
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47 inactive/sedentary; b. moderately active; c. intensely active.
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51 Adolescents were divided into two groups based on the total MET score in accordance with the
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53 prescribed parameters:
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3 a. The first group consisted of intensively exposed students who met one of two criteria:
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5 - Strong-intensive activity during at least three days a week and with a minimum of 1500 MET-
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7 min per week accumulated during the week;
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10 - Seven or more days of any combination of medium or strong-intensive activities with a
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12 minimum of 3000 MET-min per week accumulated in one week.
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14 b. The second group consisted of students moderately physically active and those physically
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16 inactive.
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19 After 12 months, all the students filled out the Adolescent Injury Checklist.

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21 Registration of injuries that required medical intervention was performed by the review of
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23 medical documentation in health care institutions (school dispensaries, a sports clinics, general
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25 practitioners offices and emergency departments of general hospitals). Data were collected
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27 during 12 months. Registration of injuries included data on the first inspection by medical staff,
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29 intervention, hospitalization, rehabilitation and exemption from physical activity.
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35 **Data Analysis**

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37 The analysis included measurement of the frequency of injuries, their severity, and type of
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39 association with a particular type of sport, and the mechanism of their origin, as well as the
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41 presence of some forms of risky behaviour in adolescents.
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45 Classification of injuries were carried out according to the International Classification of
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47 Diseases 10th revision, group XIX - injuries, poisonings and other consequences of external
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49 causes (S00-T98). Analysis of data relating to sport injuries was also performed according to the
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51 international classification of external causes of injury (International Classification of External
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53 Causes of Injuries (ICEC) version 1.2, 2004).
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3 During the statistical analysis of the data frequencies, percentages, mean, relative risk (RR), odds
4 ratio chance (OR) and the required number of patients to treat (NNT) were calculated.
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7 Comparisons and determining the existence of statistically significant difference was performed
8 by: Chi2-test (degree of freedom $df = 1$, applied Yates correction); T-test determination of
9 significance of the difference of two independent samples of the 95% CI; Multivariate analysis
10 of variance (MANOVA): Pillai's Trace, Wilks Lambda; Spearman's correlation connection
11 between variables; Logical regression using standardized β .
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RESULTS

Among 698 students enrolled in the study, 345 students were considered to be exposed to intensive physical activity and 353 students were considered as unexposed to intensive physical activity. Two students were excluded as on the repeated screening they didn't meet the inclusion criteria.

In the exposed group males accounted for almost two-thirds (63%), while in the non-exposed group females made up 80% ($\chi^2 = 128.276$, $df = 1$, $p = 0.000$).

Intensively physically active students had significantly better financial status ($t = 3.5700$, $df = 695$, $p = 0.0004$; 95% CI: -0.32557; -0.0944). They also showed better results in self-evaluation of their health ($\chi^2 = 57.888$, $df = 2$, $p = 0.000$) and they were more satisfied with their body appearance ($\chi^2 = 23.080$, $df = 5$, $p = 0.000$). Intensively physically active students were used to make friends more easily ($\chi^2 = 31.749$, $df = 3$, $p = 0.000$) compared to students who were not intensively physically active.

Risky behaviour is more likely to be frequent in intensively physically active students. A moderate level of correlation between the use of alcohol and participating in a fight was determined in this group ($r = 0.268$, $p = 0.000$). Intensively physically active students rarely felt morning fatigue, and they were less frequently on a diet compared to unexposed peers (Table 1).

No significant differences were observed between the two groups with respect to smoking, BMI, length of night sleep and time spent watching TV and using a computer.

During 12 months, 289 intensively physically active students were registered with an injury (Inc. 83.8 per 100). In the control group 42 students were registered with an injury (Inc. 11.9 per 100).

The relative risk of sustaining an injury was seven times higher in intensively physically active

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3 students (RR = 7.041; 95% CI: 6.071; 8.187; OR = 38,214; NNT = 1.391; 95% CI: 1.336,
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5 1.458), with no significant differences between males and females.

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8 The risk of suffering more than one injury was 1.4 times higher in intensively physically active
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10 adolescents, with no significant differences among males and females (RR = 1.417; 95% CI:
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12 1.024, 1.969, OR = 1.906; 95% CI: 1.044, 3.488; NNT = 6.293), (Figure 1).

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15 The most important social predictor of injuries in the group of physically active adolescents was
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17 at least one unemployed parent ($B = 0.139$, $\beta = 0.165$, $p = 0.018$) and bullying by peers ($B =$
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19 0.219 , $\beta = 0.154$, $p = 0.023$).

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22 Three-quarters (76.5%) of intensively physically active students experienced an injury on a
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24 sports field or in a sports hall. Every third student in the control group had an injury at home
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26 (35.7%), (Figure 2). The risk of suffering an injury on the sports field was eight times higher for
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28 intensively physically active students (RR = 8.033; 95% CI: 4.517; 15,465, OR = 30,888; 95%
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30 CI: 12.884; 76.210; NNT = 1.494; 95% CI: 1,324; 1,824).

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33 Three-quarters (76.5%) of physically active adolescents suffered an injury on the sports
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35 field/hall. A third of the adolescents in the control group suffered an injury at home (35.7%). The
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37 risk of suffering an injury on the sports field was eight times higher in intensely physically active
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39 adolescents (RR = 8.033; 95% CI: 4.517; 15,465, OR = 30,888; 95% CI: 12.884; 76.210; NNT =
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41 1.494; 95% CI: 1,324; 1,824).

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44 The incidence rate of sports injuries for intensively physically active students was 76.2 per 100,
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46 and in the control group it was 6.8 per 100. The relative risk of sustaining a sports injury was
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48 eleven times higher in intensely physically active adolescents (RR = 11,212; 95% CI: 9,013;
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50 14,074; OR = 43,966; 95% CI: 32,722; 59,166; NNT = 1.440).

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3 A significantly higher incidence rate was registered in males (82.9 per 100) compared to females
4 (65.1 per 100) ($\chi^2 = 14.050$, $df = 1$, $p = 0.000$, Yates: 13,088).

7 Multivariate analysis showed that the incidence of sports injuries was related to the number of
8 training sessions and the number of hours of exercise in a week (Pillai trace = 0.963; $F =$
9 3332.73, $df = (2/254)$; $p = 0.000$). Warm-up exercises ($r = 0.481$, $p = 0.000$) and BMI ($r = -$
10 0.103, $p = 0.053$) did not affect the reduction in the number of sports injuries.

13 The rate of incidence of sports injuries per 1,000 hours of exposure in the group of intensively
14 physically active students was 2.9 per 1000 h. The highest rate was related to training/a match
15 (4.9 per 1000 h). The incidence rate during leisure activities was 2.5 times lower (1.8 per 1000
16 h). The lowest rate was related to physical education in schools (0.4 per 1000 h).

19 More than 86% of all registered sports injuries occurred during organized sports activities, of
20 which two-thirds (64.7%) of the injuries were in males ($\chi^2 = 33.590$, $df = 12$, $p = 0.001$). The
21 incidence rate was the highest for football (4.4 per 1000), volleyball (3.9 per 1000) and
22 boxing/kickboxing (3.7 per 1000), (Table 2).

25 Almost 90% of intensively physically active students were not able to be physically active for
26 more than 24 h after an injury, compared with 65.9% in the control group ($\chi^2=27.266$, $df=2$,
27 $p=0.000$). A significantly higher percentage of physically active adolescents required hospital
28 treatment, extended home care and rehabilitation after injury (Table 3).

31 Temporary disability for a period not longer than six months occurred in 2.8% of participants in
32 the exposed group while in the control group there was no single case. After sustaining the injury
33 1.1% of physically active students had to give up the sport.

36 The incidence of injuries that required medical treatment was 54.2 per 100 in the group of
37 intensively physically active students and 3.7 per 100 in the control group. The relative risk for

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3 an injury that requires assistance in a medical institution was almost 15 times higher in the group
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5 of intensively physically active students (RR = 14,717, 95% CI: 10,652; 20,592; OR = 30,952,
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7 95% CI: 21,501; 44,738; NNT = 1,979). Male students suffered from an injury more often ($\chi^2 =$
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9 7.696, df = 1, p = 0.0055).
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For Peer Review

DISCUSSION

Intensively physically active students are at significantly higher risk of injury. The relative risk of all self-reported injuries was seven times, and for injuries requiring medical treatment, 15 times higher in this group of students.

Numerous studies have found a significant association between the level of physical activity and injury. Results of the Janssen et al. study¹⁵ on the population of adolescents in Canada 2001/2002 showed that the probability of severe injury associated with physical activity outside of school grows from moderate to intense physical activity (OR = 3). Regarding physical activity at school, the OR for injuries in the intensively active students was 1.5. Spinks et al.¹⁶ found in 2006 the incidence of injury from 67.7 per 100 students in Brisbane, Australia and 78.6% of injuries were directly related to physical activity.

The most common type of injury found in our study was falls. This is consistent with a number of similar studies and showed that the majority of unintentional injuries among young people occur during organized sports activities, with a significantly higher incidence in males.^{8,17,18}

The relative risk of sustaining a sports injury was 11 times higher in the group of intensively physically active adolescents and 85.2% of those were injured on the sports field, while students from the control group were injured most frequently in the school environment (37.5%).

The study by Emery et al.¹⁹ on a sample of 1466 high school students in Calgary in 2009 showed that the incidence of injury in students who have participated in sports was 60.9 per 100, and more than 40% of the students suffered more than one injury.

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3 A study²⁰ on 14-19 year old athletes in North Carolina in 2006 showed an incidence of sports
4 injuries of 72.8 per 100 for men and 27.2 per 100 females. The incidence rates per 1,000 hours of
5 exposure in intensely physically active respondents are approximately near the values in our
6 study, for 12 tested sports they were 2.1 per 1000 h, and at matches 5.0 per 1000 h.
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11 Our study showed that injuries occur almost six times more often in organized sports. The
12 highest incidence rate of injuries was recorded during training or a match (4.9 per 1000 h).
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14 According to data from Youth sports safety, 62% of injuries in organized sport occurred during
15 training²¹. Janssen et al.¹⁵ showed that the most common injuries occurred in physically active
16 students in organized sports activities outside school (OR = 2.98). A study by Verhaegen et al.²²
17 in 2009 showed that the injuries occurred mostly among students in organized sport.
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26 A quarter of all injuries of physically active students in our study which happened in organized
27 sports was related to football (4.4 per 1000). According to the results of various studies, the
28 incidence rate of injuries related to football was in the range of 4.6 to 7.9 per 1000.²³
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30 Multivariate analysis showed that a large number of training sessions and number of hours of
31 exercise increases the risk of injury. The use of protective sports equipment and warm-up
32 exercises did not affect the reduction in the number of injuries in our patients.
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40 Although numerous studies have shown that warming up and stretching leads to better flexibility
41 of ligaments, there is not enough firm evidence about reducing the risk of injury.²⁴ Similarly,
42 Thacker et al.²⁵ found that there was insufficient evidence that warming up and stretching before
43 training have an impact on reducing the risk of injury.
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49 The intensity of physical activity had no influence on reducing risky behaviour in adolescents,
50 such as the use of alcohol and violent behaviour. Results of the study confirm the empirical
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3 findings of other studies, which support the claim that physical activity does not reduce the level
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5 of violence among young people.²⁶⁻²⁸
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8 9 10 Limitations

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12 Limitations of use of self-reporting techniques are now well documented. The most common
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14 problems in the precision and accuracy of reporting on the level of physical activity are:
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16 misinterpretation of questions by respondents, the difficulty in accurately defining the duration
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18 and intensity of physical activity on the basis of memory and / or misinterpretation of the results
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20 obtained by the researchers. It was found that the questionnaires completed by respondents
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22 themselves less accurate than those completed by the interviewer.²⁹ Also, this method includes
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24 some other limitations: the difficulty in estimating the frequency, duration and intensity of
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26 physical activity, capturing the different domains of physical activity, the provision of socially
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28 desirable response, and cognitive limitations provided data on the basis of memory.^{30,31}
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35 Conclusions

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37 Intensively physically active high school students have a much higher risk of injury, which
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39 usually occurs during training or a match. There is no difference in overall injury incidence
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41 among boys and girls, but the incidence of sports injuries is significantly higher among boys.
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44 Inactive or moderate physically active high school students more often have at least one parent
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46 unemployed and they are more unsatisfied with their parents' earnings. In contrary, intensively
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48 physically active students are more likely to exhibit risk behaviours (to be involved in fights, to
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50 get drunk or to carry weapons).
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3 The risk of injuries among intensively physically active high school students emphasises the
4 need for the appropriate policies and prevention programmes, which would include better
5 education of coaches, organisers or sports events, referees, parents and students themselves.
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11 12 13 **IMPLICATIONS FOR SCHOOL HEALTH**

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15 The role of schools in promoting physical activity is essential and benefits of physical activity to
16 students are well known. However, schools need to provide safe environment for physically
17 active students and to prevent sport-related injuries.
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21 It is necessary to establish a system to monitor injuries in school and to record and evaluate all
22 injuries. Periodical evaluations will reveal injury prevention gaps and should lead to injury
23 prevention improvement activities in schools.
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29 Special attention should be paid to improving the quality of sports and recreation in schools
30 through:
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- 32 • education and preparation of children and adolescents to participate in sports
33 activities,
- 34 • impact on the behaviour of young people in sport and recreation,
- 35 • adequate supervision of training and exercises by trained licensed trainers, including
36 specific training in injury prevention,
- 37 • adequate quality and suitability for a specific purpose sports fields (accessibility,
38 security),
- 39 • provision of adequate sports and protective equipment.
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54 **Human Subject Approval Statement**

The research was approved by the Board of Ethics of the University of XXX [Blinded by request from JSH] and the Board of Ethics of the XXX [Blinded by request from JSH].

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Figure 1. Frequency of Injuries during 12 Months

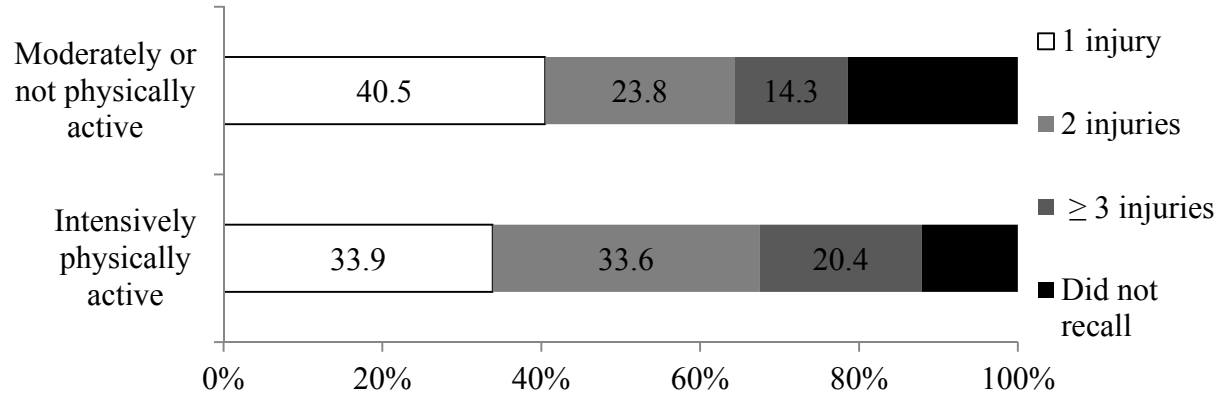


Figure 2. Location/Terrain Where the Injury Occurred

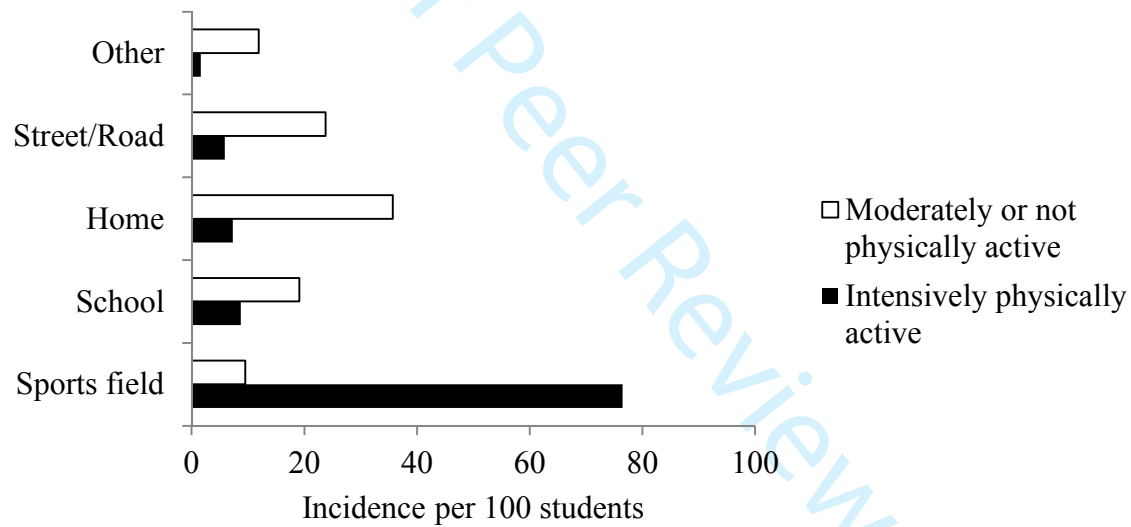


Table 1. Sociodemographic differences and differences in group behaviour

	Intensely physically active %	Physically inactive or moderately active %	Significance
Sociodemographic characteristics			
Great success in school	28.1	39.1	t=3.3933, df=696, p=0.0007; 95%CI: 0.09683; 0.36317
At least one parent unemployed	21.6	41.2	t=3.9677, df=685, p=0.0001; 95%CI: -0.56817; -0.19183
Satisfactory financial status of parents	44.1	33.2	t=3.5700, df=695, p=0.0004; 95%CI: -0.32557; -0.09443
Habits and behaviour			
Easily make friends	95.6	84.7	$\chi^2=31.749$, df=3, p=0.0001

1				
2				
3	Drunkenness ≥ 10 times	11.7	6.2	$\chi^2=13.382, df=4, p=0.010$
4				
5	in last 12 months			
6				
7				
8	Participation in a fight	3.8	0.9	$\chi^2=3.868, df=3, p=0.0001;$
9				
10	≥ 2 in last 12 months			$r=0.268, p=0.0001$
11				
12				
13				
14	Carry weapons/often or	5.2	1.2	$\chi^2=11.188, df=4, p=0.025;$
15				
16	always			$r=0.297, p=0.0001$
17				
18				
19				
20	Self-assessment of health			
21				
22	Feels very healthy	67.3	38.5	$\chi^2=57.888, df=2, p=0.0001$
23				
24				
25				
26	Satisfied with body	57.4	48.2	$\chi^2=23.080, df=5, p=0.0001$
27				
28	appearance			
29				
30				
31	Morning fatigue ≥ 4	13.9	18.4	$\chi^2=13.598, df=3, p=0.004$
32				
33	times a week			
34				
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37	On a diet	22.0	38.2	$\chi^2=21.750, df=1, p=0.0001$
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Table 2. Injuries in organized sports among exposed adolescents

Sport	% injured	Inc. per 1000 h
Football	24.9	4.4
Volleyball	10.8	3.9
Boxing/kickboxing	9.8	3.7
Basketball	8.7	3.4
Dance/folklore	7.6	3.4
Tennis	6.9	3.5
Body building/gym	6.9	2.0
Water polo	3.6	2.2
Handball	3.2	3.0
Martial arts	2.8	0.8
Athletics	2.5	3.0
Swimming	1.8	1.8
Gymnastics	0.7	2.6
Other	9.8	2.0

Table 3. Consequences and Treatment of Injuries

Consequences and treatment	Intensely physically active %	Physically inactive or moderately active %	Significance
No physical activity for ≥ 24 h	89.9	65.9	$\chi^2=27.266$, $df=2$, $p=0.001$
No physical activity for ≥ 1 month	6.2	9.4	$\chi^2=9.815$, $df=6$, $p=0.133$
Extended home care	42.6	21.4	RR=1.986, 95%CI: 1,.56;3.206; OR=2.717
Hospital treatment	8.7	4.8	$\chi^2=0.312$, $df=1$, $p=0.5764$
Rehabilitation	12.5	4.8	RR=2.618, 95%CI: 0.884;8.518; OR=2.848