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Manuscript title: From which level of competition in clubs are adolescents at greater risk of injury compared with outside-of-clubs athletes? A school-based study.

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From which level of competition in clubs are adolescents at greater risk of injury compared with outside-of-clubs athletes? A school-based study.

ABSTRACT

Objectives: Sport practice is a key factor in a person's physical and mental health but, for adolescent athletes, some injuries lead to health problems in the long term. The literature provides multiple factors for understanding injury but does not give information about injury risk related to each level of play in a large sample of multisport athletes. This study investigates this relationship in 14- to 19-year-old adolescents.

Methods: The survey on adolescents and health was conducted in classrooms of France, from February to March 2015. Only sports players were included in the analyses (n = 986). The levels of play were divided into five categories: Outside of a club/no competition, club player/no competition, club player/local level, club player/state level and club player/national and higher level. A three-step binary logistic regression analysis with age, sex, type of sport, weekly hours of exposure, and level of play was used.

Results: During the past year, 48.1% of the adolescents were injured. Age and sex were not risk factors. The injury risk associated with the increases in level of play is higher than those related to the hours of exposure per week or the type of sport. In clubs, adolescents who do not compete or play at a local level showed no evidence of greater injury risk whereas state-level and national- and higher-level athletes were at greater risk than outside-of-club players (OR= 2.18, 95%CI= 1.13-3.94 and OR= 3.89, 95%CI= 2.07-7.31, respectively).

Conclusion: Adolescents who play sports in clubs are clearly more exposed to injury than those who play outside of a club, mainly from state level. Age and sex are not related to

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injury. Future epidemiological studies should control adolescents' level of play. Special attention should be accorded to the injury risk of athletes playing at these levels of competition.

Keywords: athletic injuries; sports injury; risk factors; injury prevention; public health; sport level

Introduction

Sport practice is regarded as a key factor in a person's physical [1] and mental health [2,3] and as a means to reduce the risk of such diseases as cancer, diabetes type II or osteoporosis [4]. However, sport practice also involves significant risks. For adolescent athletes, besides immediate effects of injuries that cause pain, immobilization, and absences from school, some injuries lead to health problems in the long term [5]. For instance, knee injuries significantly increase the risk of osteoarthritis in adulthood [6]. To inform public health policies, coaches, and parents, and to guide future prevention initiatives, students most vulnerable to sports injuries need to be identified. Multiple factors are related to the occurrence of injuries (social, psychological, biomechanical, physiological) [7,8]. We can act on some of them (hours of exposure, muscles, body mass index (BMI), attitude or equipment) to reduce their influence, while others are non-modifiable because they are specific either to the sport and performance goals (type of sport, context of practice, level of competition) or to the athlete's biological characteristics (age, sex). Our study focuses mainly on non-modifiable factors that can be controlled without medical supervision or additional measurement tools (electromyography, etc.) and helps to identify groups of adolescents at high risk of injury.

Age, sex, and hours of exposure [9] have been found to increase the risk of injury in sports [10]. Regarding body mass index, longitudinal and retrospective studies have demonstrated that BMI status does not modify the relation between sport participation and injury risk

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among adolescents [11,12], except in overweight and obese populations [13-15]. Next to the greater injury risk in collective sports compared with individual sports [16], retrospective studies show that the risk of injuries is greater for those playing sports in clubs than outside of clubs [13, 17, 18]. This difference could be explained by the fact that the level of play and the related intensity of practice may be higher in clubs. These studies use the club/outside of a club context variable as an indicator of the athlete's level. However, in clubs, there are also various contexts (practice and competition) and competition levels (i.e. levels of play) which have different influences on the risk of injury. For example, in retrospective studies, the competitive context has been shown to be a risk factor [19]. Similarly, cohort studies of young high-level athletes and high-school athletes demonstrate that the risk of injuries is greater in the competitive context than in the practice context. Injury rates are higher [20, 21] and injuries are more severe [20, 22]. Regarding the influence of competition levels in clubs, existing studies on gymnastics [23] and soccer [24, 25] have shown that injury risk is higher for professional and international athletes than for amateur or state and national athletes.

Recent studies have shown that adolescents playing sports in clubs were more exposed to injury than those playing outside clubs [13, 17, 18]. However, to our knowledge, at present no study has measured, in general adolescent populations, the adolescents' odds of being injured at each level of competition in clubs compared with adolescents playing sport outside of clubs. The objective of our study was to determine the risk of injury of adolescent students related to each level of competition in clubs compared with outside of clubs while considering potential confounders (age, sex, BMI, type of sport, hours of exposure). Injury prevention is an important public health issue that should be considered to all adolescents' athletes. In addition, our findings will help to determine at which level of play a continued attention of the injury risk should be done.

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Materials and Methods

Participants

Data on French adolescents and their health were collected between February and March 2015 (n = 1343). The study was conducted on junior high-school, senior high-school, and first-year university students. All the participants responded to the survey under the supervision of a physical education teacher and a researcher. The study was authorized by the Superintendent of Schools and approved by the Aix-Marseille University Ethics Committee. Only adolescents who agreed to participate and returned signed parental informed consent forms, or those aged 18 years and over, answered the survey (response rate: 98.5%). This study included only sports players (n = 986). To define sport, we use a definition adopted by the Council of Europe (1992) [26]: 'Sport means all forms of physical activity which, through casual or organized participation, aim at expressing or improving physical fitness and mental well-being, forming social relationships or obtaining results in competition at all levels.' Following the questionnaire used by Lamprecht et al. (2015) [27] students were invited to give their sport participation outside of physical education classes at school. Thus, students were invited to answer the question: 'Apart from physical education classes at school, do you practice sports?' Those who said 'yes' were asked to report the sport they preferred to practice outside of school and their usual amount of practice per week. Preferred activities were listed in a separate table and a committee of physical education teachers and researchers in sport sciences was formed to decide whether or not these activities could be considered sports in terms of the definition of the Council of Europe (1992) [26]. Students playing their preferred activity – considered a sport by the committee – and practicing it for one hour or more per week were considered sport players.

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Instruments/Procedure

Sociodemographic, sport participation, and injury variables were used. Students reported their age (Mean = 16.83, SD = 1.81), weight, height and sex. BMI was calculated by dividing weight (kg) by height squared (m^2). Sports activities preferred by adolescents were classified under collective sports or individual sports by the same committee of physical education teachers and researchers in sport sciences. The 'weekly hours of exposure' continuous variable was divided into five equal groups (<= 2 hours, <= 3 hours, <= 5 hours, <= 7 hours, > 7 hours). Adolescents reported the sport participation context (club/outside of a club) and the level of competition (no competition, local level, state level, national and higher level). A 'level of play' variable was created by combining the sport participation context and the level of competition. Five levels of play were developed (Outside of a club, no competition; Club player, no competition; Club player at local level; Club player at state level; Club player at national and higher level). Athletes classified under Outside of a club at competitive level were excluded from the level of play analysis because there were too few of them (n = 33).

Injury was defined according to consensus statements on injury definition in soccer [28] and rugby [29]. Injury was defined as: 'Any physical complaint which is caused by a transfer of energy that exceeds the body's ability to maintain its structural and/or functional integrity, that is sustained by a player during a match or training, irrespective of the need for medical attention or time-loss from his sport activity. An injury that results in a player receiving medical attention is referred to as a "medical-attention" injury and an injury that results in a player being unable to take a full part in future training or match play as a "time-loss" injury.' As in other studies [13], we investigate risk factors for (i) all sport injury (ASI), irrespective of the need for medical attention or time-loss from adolescents' activity; (ii) injury treated by a medical practitioner – medically treated injury (MTI). As did by Backx [19] and many others studies, information about injuries were self-reported by adolescents. They were asked

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to report whether they had been injured in the past 12 months during their preferred sport activity, the numbers of injuries sustained, the nature of the injuries (sprain, overuse, tendon strain, muscle strain, contusion, fracture, dislocation) and the severity of the most serious one. For the nature and severity of injury, we used the same questions as the Western Australian Sports Injury Study (WASIS) [30]. Severity was graded into three levels. A minor injury is an injury declared as self-treated, or treated by a sports trainer, coach, parent, or similar. A moderate injury is an injury declared as treated by a medical practitioner. A severe injury is an injury requiring hospitalization. The validity of nature and severity of injury (minor and moderate) reported by the WASIS method have been previously assessed on a four-week self-report sports injury recall against external sources (hospital records, health practitioners' records, and third parties) [31]. Contrary with initial WASIS method, in this study we used a one-year self-report recall for injury. Information about the adolescents' sports experiences, mechanisms of injuries, localization, and context of the emergence (match and training) was also asked for. Results from the latter data are not reported in this article but will be used in subsequent papers on injury mechanisms.

Data Analysis

Statistical analyses were performed using SPSS 18.0.0. First, we presented in a table sample distribution by sex, type of sport, hours of exposure per week, and level of play. For each variable we report the proportions (%) of athletes who have sustained an injury in the past 12 months. Chi^2 statistics were used to measure the effect of each variable on injury. Second, we reported in a table the nature of the injuries sustained by athletes at each level of competition. Odds ratios (OR) and their 95% confidence interval were calculated. The reference category for odds ratio was injury risk for athletes playing sport outside clubs. Third, a three-step binary logistic regression was developed. Only significant variables at 0.05 during multiple regressions were included in the final model. The first step of the logistic regression model

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included the sociodemographic and anthropomorphic variables (sex, age, BMI). The second step concerned sport-related variables already known to be linked to injury (type of sport and weekly hours of exposure). The third step dealt with the main objective of this study: to investigate the link between the athletes' level of play and injury. This model was performed twice: for ASI, then for MTI. Adjusted OR estimated in these analyses are presented in Table 3 with confidence intervals and p-values and were used to approximate injury risk.

Results

The descriptive statistics and injury rates are provided in Table 1. Soccer had the highest participation rates (15.7%), followed by dance (14.5%), basketball (6.0%), tennis (5.3%), strength training (4.1%), boxing (4.1%), rugby (3.9%), swimming (3.8%), handball (3.8%), and horse riding (3.2%). 78 activities were identified. Distribution of the adolescent athletes by sport are in Additional File 1, Table 1. For information, in Additional File 1, Table 2, we present sport activities declared by the adolescents which were not considered sports by the committee.

A total of 474 (48.1%) students had suffered at least one sport injury within the past 12 months. In all, 758 injuries had been sustained. The severity was minor for 61.4%, moderate for 32.3% and severe for 6.3% of the injuries. Table 2 presents the nature of injuries sustained at each level of play and the OR for each kind of injury compared with athletes playing outside clubs. Adolescents playing sport in clubs at local level, state level, and national and higher level had a lower overuse injury risk compared with outside-of-club players (OR = 0.6, 95%CI: 0.44-0.84, OR = 0.6, 95%CI: 0.44-0.80 and OR = 0.9, 95%CI: 0.71-1.25, respectively). Adolescents playing sport in clubs at state level and national and higher level had a greater risk of tendon strain and fracture. At state level adolescents were 1.9 times more likely (95%CI: 1.36-2.66) to report a tendon strain and 13.2 times more likely (95%CI: 1.56-111.27) to report a fracture compared with outside-of-club players. At national and higher

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level, adolescents were 2.5 times more likely (95%CI: 1.76-3.50) to report a tendon strain and 14.2 times more likely (95%CI: 1.64-122.71) to report a fracture compared with outside-of-club players.

According to the multiple logistic regressions, BMI was not associated with injury (OR = 0.97, 95%CI = 0.93-1.02). Thus, it was not included in the further models. Table 3 summarizes the results from the three-step binary logistic regression model. For all injuries, in the first step there was an effect of sex (OR = 1.32, 95%CI: 1.00-1.71). In the second step, there was no evidence of an effect of sex (OR = 1.02, 95%CI: 0.77-1.36), but there was an effect of age (OR = 0.91, 95%CI: 0.84-0.98). Regarding the type of sport, collective sports players are more likely to have sustained an injury than individual sports players (OR = 1.40, 95%CI: 1.03-1.89). The risk increased as the hours of exposure grew. Athletes who practiced from 3 to more than 7 hours per week were significantly more exposed to the risk of injury than the lowest-participation group. The highest-participation group had 3.18 times the odds of sustaining an ASI than the lowest-participation group (95%CI: 2.07-4.91). In the third step, the risk of injury in collective sports compared with individual sports is the same as in the second step and the risk of injury related to the hours of exposure decreased compared with the second step. The athletes practicing between 5 hours to 7 hours per week and more than 7 hours per week have almost the same risk of injury compared with the lowest-participation group (OR = 2.27, 95%CI: 1.45-3.59 and OR = 2.38, 95%CI: 1.48-3.84, respectively). Regarding the level of play, the risk increased as this rose. In-club players who do not compete and local-level competitors had no significant greater risk of ASI than outside-of-club players (OR = 1.42, 95%CI: 0.96-2.09 and OR = 1.36, 95%CI: 0.88-2.10, respectively). In contrast, state-level and national- or higher-level players were more likely to have sustained an injury in the past year (OR = 1.64, 95%CI: 1.05-2.57 and OR = 2.39, 95%CI: 1.44-3.99, respectively).

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Regarding MTIs, in the first step, there was an effect of age (OR = 1.14, 95%CI: 1.04-1.25) and sex (OR = 1.49, 95%CI: 1.06-2.09). In the second step, these effects disappeared. Collective sport players were more likely to have sustained an injury than individual sports players (OR = 2.07, 95%CI: 1.43-2.98). As the hours of exposure increased, so did the risk. From 3 hours to more than 7 hours of exposure per week, athletes had 1.9 to 4.0 times the odds of sustaining an MTI, compared with the lowest-participation group. In the third step, age and sex did not affect the results, and the risk associated with the increase of hours of exposure decreased compared with the second step. Adolescents playing less than 7 hours per week were at no greater risk of MTIs than the lowest-participation group. The risk of injury was greater for athletes who practiced sports more than 7 hours per week (OR = 2.12, 95%CI: 1.13-3.94). Regarding the level of play, club players at a non-competitive level and at a local-level had no greater risk of MTIs than outside-of-club players, whereas the odds were 2.18 times greater for state-level players (95%CI: 1.19-3.99) and 3.89 times greater for national- and higher-level players (95%CI: 2.07-7.31).

For the reader's interest, additional logistic regression models with severity of injury are in Additional Files 2.

Discussion

We observed no increased risk with BMI for ASI and MTI. Much of this result is certainly attributed to the small number of overweight and obese adolescents in our sample (less than 5.0% and consistent with previous French studies, e.g. [32]). Effects of BMI for injury have been shown only for overweight and obese adolescents [11-15]. There was a minor effect of age for MTI but not for ASI. Regarding the sex effect, the first step of the logistic regression demonstrated that boys are more prone to injury than girls. In the second and third step, we observed an increased risk of ASI and MTI for collective sports compared with individual sports and with increasing hours of exposure per week and level of play. The sex effect then

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disappeared. Therefore, the explanatory factors were neither the age nor the athletes' sex but rather the type of sport, the weekly hours of exposure and the level of play. These results were consistent with those from scientific observations indicating no sex effect on injuries [9,13].

It has already been shown that collective sports put adolescents at a greater risk of injury than individual sports [16]. Hours of exposure have also long been recognized as a risk factor [9, 10]. In large populations of young athletes, it has also been shown that athletes in clubs are more exposed to injury than those outside clubs [13, 17, 18]. In addition to previous findings, according to our results, in a multisport population, the risk of injury in clubs varies across competitive levels. In clubs, non-competitive and local-level players showed no evidence of greater risk of injury than outside-of-club athletes. In contrast, exposure to injury in clubs compared with outside of a club increased from state level. To our knowledge, this is the first time that, in a large sample of adolescent athletes, injury risk is reported by level of play and that below state level, playing sport in clubs does not increase injury risk in adolescents compared with the outside-of-club context. Also, we observed that the introduction of the level of play in the third steps of the models (ASI and MTI) reduced the intensity of the relation between hours of exposure and injury observed in the second steps.

For ASIs, in the second step, from 3 hours to more than 7 hours of exposure per week, athletes were at greater risk of injury ranging from 1.9 to 3.2 times more than athletes practicing sports less than 2 hours per week. In the third step, this effect decreased substantially. For each group of athletes, the injury risk was lower than in the second step and athletes practicing more than 7 hours per week were not at great at greater risk compared with those playing 5 hours per week (approximately 2.3 times more risk of injury than athletes practicing less than 2 hours per week). Regarding the level of play, adolescents practicing sports at state or national- and higher-level were more likely to have sustained an injury (respectively 1.64 and 2.39 times more). As ASIs, for MTIs, in the second step, from 3 hours

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to more than 7 hours of exposure per week, athletes were at greater risk of injury, ranging from 1.9 to 4.0 times more than athletes practicing sports less than 2 hours per week. In the third step, only athletes who practiced sport more than 7 hours per week were more likely to have sustained an injury than the lowest-participation group. In contrast, risk of injury related to the level of play was notably higher for state-level and national- and higher-level athletes (respectively, 2.18 and 3.89 times more likely). This suggests that the increasing injury risk with increasing hours of exposure observed in the second step is directly related to the level of play.

Therefore, these results show that knowing the number of weekly hours of exposure is not sufficient for understanding injury. Some scientific studies highlight the importance of considering the intensity of play [13, 33, 34]. The level of competition has been shown to be positively related to the intensity of internal and external forces acting on athletes' muscular-skeletal system (e.g. soccer [35], rugby [36]) and to injury incidence and severity [20, 23, 25]. Some authors suggest that the greater risk may be due to an increase in intensity of play and contact during the game. Our results could be explained by these previous findings. We hypothesize that, in competition below state level, the increase in intensity does not affect adolescents' risk of injury whereas, above that level, it would reach a threshold that puts them at a greater risk of injury. Moreover, our results showed that adolescents playing at state level and national level had a higher risk of more serious injury than outside-of-club players. The positive association between level of play and injury was greater for MTI than for ASI. More precisely, additional analyses (see File 2) showed that the level of play was not associated with minor injury risk, whereas a high association was observed for moderate and severe injury. State level and national- and higher-level athletes reported respectively 2.71 and 5.39 times greater risk of moderate or severe injury compared with outside-of-club athletes. They are especially at greater risk of fractures. This greater risk could be also explained by a

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positive relation between level of play and intensity of internal and external forces acting on athletes' muscular-skeletal system [35-36] and is consistent with the greater incidence of severe injuries reported in competitive contexts [20, 22]. To sum up, in addition to a greater injury risk at state level and higher, adolescents were also at a greater risk of severe injuries, such as fractures. To our knowledge this is the first time that this kind of results is observed in a large sample of adolescent athletes.

The threshold effect observed at state level and above needs to be specifically studied. Researchers, coaches, parents, physical education teachers, and public health officials should try to understand this phenomenon and develop specific injury prevention programs [37, 38] toward adolescents playing sport at state level and higher. These interventions would take into account the sport that adolescents practice most and the injury pattern associated with it. The literature has shown that injury incidence and pattern vary greatly among sport activities [39, 40]. The highest injury rates are observed in motorcycling, handball, and skating; and contact sport players are at greater risk of fractures or dislocation. In other sports, such as climbing, tendinopathy is the most common injury [41]. Obviously, characteristics of sport activity are linked to the localization of injury. Public health officials, coaches, as well as parents or physical education teachers, should consider sports playing by adolescents and could develop appropriate preventive initiatives. Relevant sport and injury specific prevention programs [36, 37] can be found in sports sciences journals.

Limitations

Variation of injury incidence and pattern among sport activities leads to the major limitations of our work. The sports included in our sample are heterogeneous, and conclusions would certainly be different if the sport sample changed. Similar analyses conducted in other samples should be made. In addition to the increased risk for collective sports compared with individual sports, another classification exists, based on the probability of contact with the

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environment or the adversary and the related dangerousness. A classification developed by the Committee on Sports Medicine and Fitness [42] categorizes sport activities according to this criterion. Future studies could examine the influence of the level of play on injury while considering this classification. In our opinion, the absence of consensus with respect to the classification system to be used demands that they all be taken into account so that the most relevant one for this study object can be determined. A literature review regarding the links found between each sport classification and the injuries rates could be useful.

Secondly, our results did not bring information about the injury risk for athletes who play sports outside of clubs and who compete. Our sample number was not sufficient to perform reliable statistical analyses. Thus, it is impossible to know whether the level of competition is more determinant than the context of sport participation to understand injury occurrence. As we observed for athletes who do not compete both in clubs and outside of clubs, it is plausible that athletes playing outside of clubs and who compete have the same risk of injury as athletes playing in clubs and who compete. However, it is also possible that the context of sport participation is more determinant, in other words, that athletes playing outside of clubs and who compete have a lower injury risk than those playing in clubs who do not compete. No study provides evidence to answer this question. Further research is needed.

The retrospective design is another weakness of our study. Although we used a retrospective report for injury which has shown good reliability, some authors have pointed out that retrospective reports of injuries in youth and adolescents were not precise enough for back pain symptoms [43]. Due to our 12-months recall period for injury, it is possible that some injuries had been forgotten by the adolescents. Further studies should develop longitudinal analyses to assess the validity of this result over a long time period. For example, further studies could ask adolescents every month about the injuries they had sustained in the

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previous four weeks. These studies would help determine more precisely the adolescents' injury risk for each level of play.

Conclusions

Age and sex are not related to injury. However, the 'level of play' variable, created by combining the context of sport practice and the level of competition, is relevant to understanding the occurrence of injuries. This variable as well as the hours of exposure per week help to identify the most vulnerable populations. Moreover, increases in level of play put adolescents at greater risk of injury more than increases in hours of play per week. This effect could be due to the positive association between level of play and intensity. Adolescents who play sports in clubs are clearly more exposed to injury than those who play outside of a club mainly from state level. At this level and higher, adolescents were also at greater risk of fracture. Future epidemiological studies should control adolescent's level of play. For example, recent studies have shown that the younger and more exclusive the sports specialization is, the greater the injury risk, irrespective of context of participation, sex, BMI, or hours of play per week [18, 44, 45]. One could argue that the level of play should mediate this relation. A high level of specialization without a high level of play could not be associated with a greater injury risk, whereas the opposite should be true. Future studies could be developed to test this hypothesis. In a public health perspective, a special attention should be done regarding the injury risk of adolescents playing sport at state level and higher.

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Table 1 Description variables

Variables		n	%	Sports Injury % (n)	
*Sex**					
	Girls	448	45.4%	44.2%	(198)
	Boys	538	54.6%	51.3%	(276)
*Type of sport****					
	Individual	668	67.7%	43.9%	(293)
	Collective	318	32.3%	56.9%	(181)
*Hours of exposure per week****					
	<= 2	252	25.6%	34.9%	(88)
	<= 3	156	15.8%	40.4%	(63)
	<= 5	241	24.4%	49.0%	(118)
	<= 7	168	17.0%	59.5%	(100)
	> 7	169	17.1%	62.1%	(105)
*Level of play****					
	Outside of a club, no competition	199	20.2%	35.7%	(71)
	Club player, no competition	280	28.4%	42.5%	(119)
	Club player at local level	173	17.5%	50.3%	(87)
	Club player at state level	176	17.8%	57.4%	(101)
	Club player at national and higher level	125	12.7%	66.4%	(83)
	Other	33	3.3%		
Had at least one injury in the past 12 months					
	No	512	51.9%		
	Yes	474	48.1%		

*$p<0.05$; **$p<0.01$; ***$p<0.001$

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Table 2 Nature of injuries sustained according to level during the past 12 months and odds ratio (OR) with 95% confidence interval (95%CI)

All sport	Outside of a club, no competition			Club player, no competition			Club player at local level			Club player at state level			Club player at national and higher level			All
N	199			280			173			176			125			953
N athletes injured	71			119			87			101			83			461
% injured	35.7%			42.5%			50.3%			57.4%			66.4%			48.4%
	% (n)	OR	95%CI	% (n)	OR	95%CI	% (n)	OR	95%CI	% (n)	OR	95%CI	% (n)	OR	95%CI	% (n)
Sprain	30.8% (33)	1.0		25.3% (45)	0.7	(0.58-0.84)	30.1% (37)	0.9	(0.70-1.04)	32.7% (55)	1.4	(1.14-1.66)	26.6% (42)	1.2	(0.96-1.45)	28.9% (212)
Overuse	15.9% (17)	1.0		**19.1% (34)**	**1.3**	**(1.01-1.6)**	**11.4% (14)**	**0.6**	**(0.44-0.84)**	**9.5% (16)**	**0.6**	**(0.44-0.8)**	12.0% (19)	0.9	(0.71-1.25)	13.6% (100)
Tendon strain	9.3% (10)	1.0		8.4% (15)	0.9	(0.6-1.28)	7.3% (9)	0.7	(0.44-1.13)	**14.3% (24)**	**1.9**	**(1.36-2.66)**	**15.2% (24)**	**2.5**	**(1.76-3.50)**	11.2% (82)
Muscle strain	17.8% (19)	1.0		10.7% (19)	0.5	(0.4-0.68)	17.1% (21)	0.9	(0.67-1.13)	14.9% (25)	0.9	(0.70-1.15)	17.1% (27)	1.3	(1.03-1.69)	15.1% (111)
Contusion	22.4% (24)	1.0		29.8% (53)	1.6	(1.3-1.9)	25.2% (31)	1.1	(0.87-1.35)	14.3% (24)	0.6	(0.48-0.77)	16.5% (26)	0.9	(0.71-1.13)	21.5% (158)
Fracture	0.9% (1)	1.0		5.1% (9)	5.7	(0.62-52.92)	7.3% (9)	8.1	(0.87-75.18)	**9.5% (16)**	**13.2**	**(1.56-111.27)**	**8.9% (14)**	**14.2**	**(1.64-122.71)**	6.7% (49)
Dislocation	2.8% (3)	1.0		1.7% (3)	0.6	(0.15-2.27)	1.6% (2)	0.5	(0.10-2.88)	4.8% (8)	1.9	(0.76-5.03)	3.8% (6)	1.8	(0.63-4.97)	3.0% (22)
N injuries	107			178			123			168			158			734

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Table 3 Binary logistic regression model and injury

Step	Type	Predictors	All Sports Injury			Medically Treated Sports Injury		
			OR	95%CI	R^2	OR	95%CI	R^2
1	*Sociodemographic predictor*				0.01			0.02
		Age	0.96	[0.89; 1.03]		1.14**	[1.04; 1.25]	
		Sex[a]	1.32*	[1.02; 1.71]		1.49*	[1.06; 2.09]	
2	*Sociodemographic predictor*				0.08			0.11
		Age	0.91**	[0.84; 0.98]		1.07	[0.97; 1.17]	
		Sex[a]	1.02	[0.77; 1.36]		0.99	[0.68; 1.43]	
	Type of sport							
		Collective[b]	1.40*	[1.03; 1.89]		2.07***	[1.43; 2.98]	
	Hours of exposure per week[c]							
		<= 3	1.20	[0.79; 1.83]		1.10	[0.56; 2.16]	
		<= 5	1.85***	[1.28; 2.69]		1.88*	[1.08; 3.26]	
		<= 7	2.74***	[1.79; 4.19]		2.72***	[1.53; 4.81]	
		> 7	3.18***	[2.07; 4.91]		4.03***	[2.30; 7.06]	
3	*Sociodemographic predictor*				0.09			0.15
		Age	0.92*	[0.85; 0.99]		1.09	[0.99; 1.20]	
		Sex[a]	1.05	[0.79; 1.40]		1.00	[0.68; 1.46]	
	Type of sport							
		Collective[b]	1.40*	[1.01; 1.92]		1.93***	[1.30; 2.86]	
	Hours of exposure per week[b]							
		<= 3	1.15	[0.75; 1.75]		0.97	[0.49; 1.94]	
		<= 5	1.71**	[1.17; 2.51]		1.47	[0.83; 2.61]	
		<= 7	2.27***	[1.45; 3.56]		1.72	[0.93; 3.17]	
		> 7	2.38***	[1.48; 3.84]		2.12*	[1.13; 3.94]	
	Level of play[c]							
		Club no competitor	1.42	[0.96; 2.09]		1.01	[0.54; 1.88]	
		Club local level	1.36	[0.88; 2.10]		1.56	[0.84; 2.92]	
		Club state level	1.64*	[1.05; 2.57]		2.18**	[1.19; 3.99]	
		Club national and higher level	2.39***	[1.44; 3.99]		3.89***	[2.07; 7.31]	

Note. OR = odds ratio; 95%CI = 95% Confidence Interval; [a]The reference category is *girls*; [b]The reference category is individual sport; [c]The reference category is *less than 2 hours*; [d]The reference category is *unorganized no competitor*; *p <.05, **p <0.01, ***p <0.001.

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Additional file 1. Table 1.

List of preferred sport activities practiced by adolescents and considered as sport according to the Council of Europe definition

SPORT	N	%	Type of sport
AEROBIC	3	0,3%	INDIVIDUAL
AIKIDO	4	0,4%	INDIVIDUAL
AIRSOFT	1	0,1%	COLLECTIVE
AMERICAN FOOTBALL	3	0,3%	COLLECTIVE
ARTISTIC GYMNASTIC	6	0,6%	INDIVIDUAL
ATHLETICS	25	2,5%	INDIVIDUAL
BADMINTON	31	3,1%	INDIVIDUAL
BALLET DANCE	5	0,5%	INDIVIDUAL
BASEBALL	1	0,1%	COLLECTIVE
BASKET-BALL	59	6,0%	COLLECTIVE
BIKING	6	0,6%	INDIVIDUAL
BMX	5	0,5%	INDIVIDUAL
BMX BICROSS	1	0,1%	INDIVIDUAL
BOXING	40	4,1%	INDIVIDUAL
CLIMBING	15	1,5%	INDIVIDUAL
CROSS-COUNTRY CYCLING	10	1,0%	INDIVIDUAL
CYCLING	5	0,5%	INDIVIDUAL
DANCING	124	12,6%	INDIVIDUAL
FENCING	3	0,3%	INDIVIDUAL
FIGURE SKATING	1	0,1%	INDIVIDUAL
FITNESS	12	1,2%	INDIVIDUAL
FRENCH BOXING	8	0,8%	INDIVIDUAL
GOLF	2	0,2%	INDIVIDUAL
GYMNASTIC	22	2,2%	INDIVIDUAL
HANDBALL	37	3,8%	COLLECTIVE
HIP-HOP DANCE	9	0,9%	INDIVIDUAL
HORSE RIDING	32	3,2%	INDIVIDUAL
ICE HOCKEY	2	0,2%	COLLECTIVE
ICE SKATING	1	0,1%	INDIVIDUAL
JUDO	16	1,6%	INDIVIDUAL
JUJITSU	3	0,3%	INDIVIDUAL
KARATE	13	1,3%	INDIVIDUAL
KAYAK	1	0,1%	INDIVIDUAL
KENDO	1	0,1%	INDIVIDUAL
KRAV MAGA	2	0,2%	INDIVIDUAL
KUNG FU	1	0,1%	INDIVIDUAL
LONGBOARDING	2	0,2%	INDIVIDUAL
MARTIAL ARTS	3	0,3%	INDIVIDUAL
MIXED-MARTIAL ARTS	1	0,1%	INDIVIDUAL
MODERN JAZZ DANCE	3	0,3%	INDIVIDUAL
MOTOCROSS RIDING	4	0,4%	INDIVIDUAL
ORIENTAL DANCE	1	0,1%	INDIVIDUAL
ORIENTEERING RACE	3	0,3%	INDIVIDUAL
PARKOUR	3	0,3%	INDIVIDUAL

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RESCUE SWIMMING	1	0,1%	INDIVIDUAL
ROLLER DANCE	1	0,1%	INDIVIDUAL
ROLLER HOCKEY	1	0,1%	COLLECTIVE
ROLLER SKATING	1	0,1%	INDIVIDUAL
ROWING	2	0,2%	INDIVIDUAL
RUGBY FOOTBALL	38	3,9%	COLLECTIVE
RUNNING	29	2,9%	INDIVIDUAL
RYTHMIC GYMNASTIC	3	0,3%	INDIVIDUAL
SAILING	1	0,1%	INDIVIDUAL
SAMBO BOXING	1	0,1%	INDIVIDUAL
SCUBA DIVING	1	0,1%	INDIVIDUAL
SELF DEFENSE	3	0,3%	INDIVIDUAL
SHOOTING SPORT	1	0,1%	INDIVIDUAL
SKATEBOARDING	5	0,5%	INDIVIDUAL
SKIING	9	0,9%	INDIVIDUAL
SOCCER	155	15,7%	COLLECTIVE
SQUASH	5	0,5%	INDIVIDUAL
STRENGHT TRAINING	40	4,1%	INDIVIDUAL
SURFING	9	0,9%	INDIVIDUAL
SWIMMING	37	3,8%	INDIVIDUAL
SYNCHRONIZED SWIMMING	4	0,4%	COLLECTIVE
TABLE TENNIS	2	0,2%	INDIVIDUAL
TAEKWONDO	5	0,5%	INDIVIDUAL
TENNIS	52	5,3%	INDIVIDUAL
THAI BOXING	9	0,9%	INDIVIDUAL
TRAIL RUNNING	1	0,1%	INDIVIDUAL
TRAMPOLINING	2	0,2%	INDIVIDUAL
TRIATHLON	2	0,2%	INDIVIDUAL
VOLLEY-BALL	21	2,1%	COLLECTIVE
WINDSURFING	8	0,8%	INDIVIDUAL
YOGA	2	0,2%	INDIVIDUAL
YOSEIKAN BUDO	1	0,1%	INDIVIDUAL
ZUMBA DANCE	4	0,4%	INDIVIDUAL
All	986	1	

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Additional file 2 Binary logistic regression model and injury severity

Step	Type	Predictors	Minor[w]			Moderate[x]			Severe[y]			Moderate+Severe[z]		
			OR	95% CI	R^2	OR	95% CI	R^2	OR	95% CI	R^2	OR	95% CI	R^2
1	*Sociodemographic predictor*				0.01			0.06			0.18			0.09
		Age	1.04	[0.95 ; 1.14]		1.28***	[1.13 ; 1.44]		2.08***	[1.49 ; 2.89]		1.34***	[1.19 ; 1.50]	
		Sex[a]	1.30	[0.96 ; 1.77]		1.68**	[1.13 ; 2.49]		2.25	[0.97 ; 5.23]		1.76**	[1.21 ; 2.56]	
2	*Sociodemographic predictor*				0.08			0.27			0.37			0.30
		Age	1.02	[0.93 ; 1.12]		1.21**	[1.06 ; 1.37]		1.99***	[1.42 ; 2.78]		1.25***	[1.11 ; 1.42]	
		Sex[a]	1.04	[0.74 ; 1.46]		0.82	[0.51 ; 1.32]		1.09	[0.40 ; 2.94]		0.89	[0.57 ; 1.40]	
	Type of sport													
		Collective[b]	1.17	[0.79 ; 1.72]		2.97***	[1.82 ; 4.83]		1.58	[0.61 ; 4.07]		2.70***	[1.70 ; 4.28]	
	Hours of exposure per week[c]													
		<= 3	1.15	[0.72 ; 1.84]		1.03	[0.50 ; 2.13]		1.30	[0.08 ; 21.71]		1.07	[0.53 ; 2.16]	
		<= 5	1.82**	[1.18 ; 2.79]		2.05*	[1.11 ; 3.82]		12.67*	[1.55 ; 103.72]		2.49**	[1.38 ; 4.50]	
		<= 7	2.56***	[1.54 ; 4.23]		3.42***	[1.76 ; 6.63]		18.53**	[2.16 ; 158.68]		4.09***	[2.16 ; 7.73]	
		> 7	4.87***	[2.63 ; 9.01]		11.69***	[5.64 ; 24.21]		61.30***	[6.95 ; 541.01]		13.09***	[6.45 ; 26.56]	
3	*Sociodemographic predictor*				0.09			0.32			0.41			0.35
		Age	1.03	[0.93 ; 1.13]		1.24**	[1.09 ; 1.42]		2.02***	[1.42 ; 2.88]		1.29***	[1.13 ; 1.46]	
		Sex[a]	1.08	[0.76 ; 1.53]		0.90	[0.55 ; 1.48]		1.24	[0.44 ; 3.53]		0.97	[0.61 ; 1.55]	
	Type of sport													
		Collective[b]	1.17	[0.78 ; 1.76]		2.64***	[1.57 ; 4.44]		1.15	[0.41 ; 3.21]		2.36***	[1.45 ; 3.86]	
	Hours of exposure per week[b]													
		<= 3	1.09	[0.68 ; 1.75]		0.89	[0.42 ; 1.88]		1.04	[0.06 ; 17.86]		0.93	[0.45 ; 1.93]	
		<= 5	1.70*	[1.09 ; 2.66]		1.59	[0.83 ; 3.06]		7.76	[0.89 ; 67.85]		1.92*	[1.03 ; 3.58]	
		<= 7	2.22**	[1.30 ; 3.79]		1.94	[0.94 ; 4.02]		9.13	[0.98 ; 85.58]		2.33*	[1.16 ; 4.68]	
		> 7	4.18***	[2.19 ; 7.99]		5.33***	[2.36 ; 12.04]		23.68**	[2.35 ; 238.52]		5.90***	[2.69 ; 12.96]	
	Level of play[c]													
		Club no competitor	1.43	[0.91 ; 2.24]		1.18	[0.58 ; 2.39]		0.58	[0.09 ; 3.97]		1.10	[0.56 ; 2.16]	
		Club local level	1.32	[0.79 ; 2.23]		1.71	[0.80 ; 3.63]		2.36	[0.49 ; 11.39]		1.81	[0.90 ; 3.66]	
		Club state level	1.65	[0.94 ; 2.88]		2.71**	[1.29 ; 5.69]		3.51	[0.73 ; 16.78]		2.71**	[1.34 ; 5.46]	
		Club national and higher level	1.81	[0.92 ; 3.55]		5.38***	[2.37 ; 12.19]		3.99	[0.74 ; 21.68]		5.39***	[2.48 ; 11.73]	

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Note. OR = odds-ratio; 95% CI = 95% Confidence Interval; [a]The reference category is *girls*; [b]The reference category is individual sport; [c]The reference category is *less than 2 hours*; [d]The reference category is *unorganized no competitor*; **p* <.05, ***p* <0.01, ****p* <0.001 ; [w]At least one minor injury (1)/No injury (0) ; [x]At least one moderate injury (1)/No injury (0) ; [y]At least one severe injury (1)/No injury (0) ; [z]At least one moderate or severe injury (1)/No injury (0)

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