



Received: 22 February 2019  
Accepted: 23 September 2019  
First Published: 07 October 2019

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## SPORTS & EXERCISE | RESEARCH ARTICLE

# Injuries in Swedish floorball players: A nationwide matched cohort study

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**Abstract:** The aim of this study was to investigate injury incidence and patterns in female and male floorball players of different ages compared with matched controls. This study involved all floorball players in Sweden and licensed during 2010–2012, and matched controls selected from Sweden’s Total Population Register. Injury diagnoses were acquired from national health care registers. The cohort comprised 148,372 players and 614,678 controls, with the median age 13 (range, 6–69) years. In most age groups, players were at increased risk of traumatic injury, particularly knee and eye injuries. The incidence of cruciate ligament injury increased steeply from the ages of 13 years in girls and 16 years in boys, and was more than 7 times higher in female players aged  $\geq 16$  years than in controls. The risk of eye injury for floorball players compared to controls was increased from the age of 10 years in male players and approximately doubled from the age of 13 years; in adult female players this risk was more than 6 times higher than in controls. Development and implementation of injury prevention measures are essential so that floorball players can safely practice their sport. Given the increased risk of injuries seen also in young players, such measures should be applied in all age categories.

**Subjects:** Sports and Leisure; Sport and Exercise Science; Sports Coaching; Sports Medicine and Therapy

**Keywords:** floorball; sports; injury; epidemiology; register study

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### PUBLIC INTEREST STATEMENT

Floorball has developed from a recreational activity into one of the most rapidly growing organized sports. This fun indoor sport involves fast movements; accelerations, sudden stops, and rapid variation in movement directions. Unfortunately, floorball seems to be related with variety of injuries. Therefore, this study aimed to investigate injuries both in male and female floorball players. Our findings indicate that floorball players of most ages have higher risk than controls for injuries, most pronounced for eye and cruciate ligament injuries. The development and implementation of injury prevention measures, such as specific training programmes and rules regarding the use of protective eyewear, are crucial so that floorball players can safely practice their sport.

## 1. Introduction

Floorball is a relatively new indoor sport that has grown rapidly during the 30 years of its existence. It is played on a 40 × 20 m court surrounded by a 0.5 m high rink with two teams consisted of a five field players and a goalkeeper. The field players have a stick and the game is played with an approximately 7 cm diameters plastic ball in three 20 minutes-periods. Floorball is now widespread and played recreationally and competitively. The International Floorball Federation has 62 member associations, and its most recent statistics show that there are about 300,000 licensed players and slightly more than 3 million recreational players worldwide (IFF, 2016). Floorball play involves accelerations, sudden stops, and pivoting movements; although floorball has been classified as a non-contact sport, it entails an inherent risk of injury. However, epidemiological knowledge of injuries among floorball players is limited.

A few previous studies have examined the frequency and severity of injuries among floorball players at different levels though mainly in adult players (Aman, Forssblad, & Henriksson-Larsen, 2016; Löfgren, A, Björnstig, & Lorentzon, 1994; Pasanen et al., 2008; Snellman et al., 2001; Tranaeus, Gotesson, & Werner, 2016; Wikstrom & Andersson, 1997). Some of these studies have investigated injury rates over single seasons in cohorts of 238–457 floorball players. Reported injury rates vary widely: per 1000 training hours, they range from 0.8 to 1.0 in men and from 1.0 to 1.8 in women; per 1000 match hours, they range from 9.3 to 23.7 in men and from 8.2 to 40.3 in women (Pasanen et al., 2008; Snellman et al., 2001; Tranaeus et al., 2016; Wikstrom & Andersson, 1997). The majority of reported injuries were classified as traumatic, and most affected the lower limb. However, these studies have not produced consistent results in terms of sex differences; older studies showed higher incidences of most injuries in men, (Löfgren et al., 1994; Snellman et al., 2001; Wikstrom & Andersson, 1997) whereas more recent studies showed that women are at greater risk of injury (Aman et al., 2016; Pasanen et al., 2008; Tranaeus et al., 2016).

Eye injuries, caused by the ball, stick or body part (Leivo, Haavisto, & Sahraravand, 2015), appear to be very common in floorball players. A few previous studies have shown that floorball is a high-risk sport with regard to these injuries, and that the majority of floorball players seeking treatment for floorball-related eye trauma are men (Bro & Ghosh, 2016; Drolsum, 1999; Leivo et al., 2015; Leivo, Puusaari, & Makitie, 2007; Maxen, Kuhl, Krastl, & Filippi, 2011). Only two of these studies (Leivo et al., 2015, 2007) had prospective designs and neither of them was conducted in Sweden, the country with the largest number of floorball players worldwide.

To date, only one study has examined injury rates in floorball-playing youths (Pasanen et al., 2017). Furthermore, no study has comprehensively compared patterns of injuries caused by floorball with those seen in controls. To optimize the conditions for effective measures aiming to reduce floorball-related injuries, a holistic overview of injury patterns in floorball players, taking sex and age into account, is needed. Thus, the primary aims of the present study were to prospectively estimate injury incidences in floorball players of different ages, and to compare them with those in age- and sex-matched controls using population-based national registers.

## 2. Methods

All floorball players aged  $\geq 6$  years with Swedish civic numbers who were members of a club belonging to the Swedish Floorball Association during the 2010–2011 and/or 2011–2012 seasons were considered for inclusion in this study. Each participant was included in the study for 1 year, from 1 September 2010 for players who held a license and was at least 6 years old in 2010, or 1 September 2011 for players who did not meet the inclusion criteria during the first year of the study. Up to 5 controls per player, matched according to sex, age, and municipality of residence, were drawn from Sweden's Total Population Register, administered by Statistics Sweden. The final study cohort comprised 148,372 floorball players (108,865 male, 39,507 female) and 614,678 matched controls (431,833 male, 182,845 female) with an age range of 6–69 (median 13) years.

**Table 1. Age and sex distribution of the study cohort**

Group		Age (years)				
		6–9	10–12	13–15	16–19	≥20
Male	Players (n)	31,381	26,107	19,351	12,137	19,889
	Controls (n)	100,376	90,168	81,788	60,111	99,390
Female	Players (n)	9100	10,331	8630	6001	5445
	Controls (n)	39,352	45,937	40,532	29,831	27,193
Total	Players (n)	40,481	36,438	27,981	18,138	25,334
	Controls (n)	139,728	136,105	122,320	89,942	126,583

The participants were stratified in groups by sex and age (6–9, 10–12, 13–15, 16–19, and ≥ 20 years) (Table 1).

The cohort was delivered from Statistics Sweden to the National Board of Health and Welfare, where the individual civic numbers were used to acquire data from the National Patient Register (NPR) and the Dental Health Register (DHR). Before delivery to the researchers, the data was encoded and depersonalised. The local ethics committee of Umeå University granted permission to conduct this study (Dnr 2013-254-31Ö).

The NPR contains data on all hospitalisations and medical consultations occurring within public specialist health care in Sweden, coded according to the Swedish version of the International Classification of Diseases, version 10 (ICD-10). The validity of diagnoses recorded in the NPR is generally high; in a large review conducted by Ludvigsson et al., (Ludvigsson et al., 2011) positive predictive values for most diagnoses were 85–95%. In the present study, we used the NPR to trace diagnoses of eye injury, face fracture/dislocation, knee sprain, cruciate ligament injury, fracture in the foot or lower leg, ligament injury in the ankle or foot, and fracture in the upper extremity. The ICD codes included are listed in supplemental table S1.

Dental injuries were traced using the NPR and the DHR, which is a register of all procedures reported by dentists to the National Social Insurance Agency falling within the governmental dental health support system for citizens aged ≥ 20 years. Children and adolescents receive free dental health care in Sweden, data on which is not included in this register. For the present study, we used the DHR to trace diagnoses of dental fracture and tooth loss.

(Supplemental table S1)

The Stata software (version 13.1 for Windows; StataCorp, College Station, TX, USA) was used for statistical analyses. The 1-year incidence of injury in players compared with matched controls was evaluated with conditional logistic regression models.

### 3. Results

The distribution of participants according to age and sex is shown in Table 1. Table 2 shows the incidence of each type of injury, along with odds ratios (OR) for injuries in players compared with matched controls.

In absolute numbers, fractures of the upper extremity were the most common injuries in children, whereas ligament injuries in the ankle/foot and knee were most common in teenagers and adults, along with dental injuries in adults. In the youngest players (aged 6–9 years), the incidence of most injuries was similar to that in controls, but floorball-playing boys were at increased risk of knee injury and upper extremity fracture (ORs, 1.15–4.17). In most age groups, players were at increased risk of ankle/foot ligament injuries compared with

**Table 2. Incidence of and odds ratios for injuries in floorball players compared with controls**

Injury type		Male						Female					
		6-9 years	10-12 years	13-15 years	16-19 years	≥20 years	6-9 years	10-12 years	13-15 years	16-19 years	≥20 years		
Eye injury	Incidence	60 (0.19%)	65 (0.25%)	61 (0.32%)	44 (0.36%)	84 (0.42%)	9 (0.10%)	14 (0.14%)	13 (0.15%)	12 (0.20%)	24 (0.44%)		
	Controls	211 (0.21%)	163 (0.18%)	116 (0.14%)	100 (0.17%)	173 (0.17%)	37 (0.09%)	37 (0.08%)	35 (0.09%)	15 (0.05%)	20 (0.07%)		
Face fracture or dislocation	Incidence	0.93 (0.70-1.26)	<b>1.37 (1.02-1.84)</b>	<b>2.26 (1.66-3.09)</b>	<b>2.18 (1.53-3.11)</b>	<b>2.45 (1.88-3.18)</b>	1.16 (0.56-2.41)	1.75 (0.94-3.24)	1.81 (0.96-3.42)	<b>3.87 (1.81-8.29)</b>	<b>6.20 (3.39-11.32)</b>		
	Controls	17 (0.05%)	23 (0.09%)	26 (0.13%)	52 (0.43%)	60 (0.30%)	4 (0.04%)	3 (0.03%)	8 (0.09%)	15 (0.25%)	5 (0.09%)		
Dental injury	Incidence	0.94 (0.54-1.63)	0.95 (0.60-1.52)	0.88 (0.58-1.34)	<b>1.53 (1.12-2.09)</b>	<b>1.50 (1.13-2.01)</b>	1.11 (0.33-3.68)	0.42 (0.13-1.38)	1.04 (0.48-2.23)	<b>4.96 (2.43-10.15)</b>	2.5 (0.85-7.31)		
	Controls	61 (0.06%)	84 (0.09%)	136 (0.17%)	168 (0.28%)	200 (0.20%)	11 (0.03%)	32 (0.07%)	38 (0.09%)	15 (0.05%)	10 (0.04%)		
Upper extremity fracture	Incidence	642 (2.05%)	773 (2.96%)	696 (3.60%)	212 (1.75%)	220 (1.11%)	174 (1.91%)	268 (2.59%)	117 (1.36%)	52 (0.87%)	38 (0.70%)		
	Controls	1,770 (1.76%)	2,500 (2.77%)	2,519 (3.08%)	984 (1.64%)	976 (0.98%)	665 (1.69%)	1,017 (2.21%)	402 (0.99%)	173 (0.58%)	117 (0.43%)		
Knee sprain	Incidence	42 (0.13%)	99 (0.38%)	127 (0.66%)	176 (1.45%)	298 (1.50%)	13 (0.14%)	40 (0.39%)	133 (1.54%)	142 (2.37%)	116 (2.13%)		
	Controls	85 (0.08%)	215 (0.24%)	454 (0.56%)	458 (0.76%)	526 (0.53%)	32 (0.08%)	138 (0.30%)	261 (0.64%)	152 (0.51%)	82 (0.30%)		
Cruciate ligament injury	Incidence	5 (0.02%)	13 (0.05%)	28 (0.14%)	52 (0.43%)	99 (0.50%)	2 (0.02%)	1 (0.01%)	39 (0.45%)	67 (1.12%)	45 (0.83%)		
	Controls	4 (0.0004%)	14 (0.02%)	63 (0.08%)	133 (0.22%)	160 (0.16%)	2 (0.01%)	15 (0.03%)	54 (0.13%)	41 (0.14%)	32 (0.12%)		
OR (95% CI)	Incidence	<b>4.17 (1.07-16.22)</b>	<b>3.23 (1.49-7.00)</b>	<b>1.80 (1.15-2.83)</b>	<b>1.96 (1.42-2.71)</b>	<b>3.09 (2.41-3.97)</b>	3.78 (0.51-27.73)	0.31 (0.04-2.34)	<b>3.54 (2.34-5.38)</b>	<b>8.17 (5.54-12.05)</b>	<b>7.51 (4.70-12.00)</b>		
	Controls	1.64 (1.12-2.39)	<b>1.62 (1.27-2.07)</b>	1.20 (0.98-1.47)	<b>1.93 (1.62-2.30)</b>	<b>2.86 (2.48-3.30)</b>	1.81 (0.95-3.47)	1.32 (0.93-1.89)	<b>2.47 (2.00-3.06)</b>	<b>4.75 (3.77-5.98)</b>	<b>7.32 (5.49-9.75)</b>		

(Continued)

**Table 2. (Continued)**

Injury type		Male						Female					
		6-9 years	10-12 years	13-15 years	16-19 years	≥20 years	6-9 years	10-12 years	13-15 years	16-19 years	≥20 years		
Ankle/foot ligament injury	Incidence	108 (0.34%)	136 (0.52%)	131 (0.68%)	158 (1.30%)	191 (0.96%)	34 (0.37%)	74 (0.72%)	96 (1.11%)	73 (1.22%)	55 (1.01%)		
	Controls	341 (0.34%)	383 (0.42%)	486 (0.59%)	372 (0.62%)	437 (0.44%)	117 (0.30%)	241 (0.52%)	243 (0.60%)	154 (0.52%)	90 (0.33%)		
Foot/lower leg fracture	OR (95% CI)	1.02 (0.82-1.28)	<b>1.25 (1.02-1.53)</b>	1.18 (0.97-1.44)	<b>2.13 (1.76-2.57)</b>	<b>2.19 (1.85-2.60)</b>	1.30 (0.89-1.91)	<b>1.40 (1.08-1.82)</b>	<b>1.90 (1.50-2.42)</b>	<b>2.37 (1.79-3.13)</b>	<b>3.09 (2.21-4.35)</b>		
	Incidence	108 (0.34%)	187 (0.72%)	170 (0.88%)	77 (0.63%)	99 (0.50%)	29 (0.32%)	74 (0.72%)	36 (0.42%)	17 (0.28%)	19 (0.35%)		
Foot/lower leg fracture	Controls	408 (0.41%)	640 (0.71%)	739 (0.90%)	335 (0.56%)	422 (0.42%)	135 (0.34%)	246 (0.54%)	177 (0.44%)	104 (0.35%)	91 (0.33%)		
	OR (95% CI)	0.82 (0.66-1.02)	0.97 (0.82-1.15)	0.97 (0.82-1.15)	1.14 (0.89-1.47)	1.17 (0.94-1.46)	0.91 (0.61-1.37)	<b>1.36 (1.05-1.77)</b>	0.97 (0.68-1.40)	0.81 (0.49-1.36)	1.04 (0.64-1.72)		

Bold values are statistically significant. OR, odds ratio; CI, confidence interval

controls (ORs, 1.02–3.09), whereas the incidence of fractures in this region was similar in players and controls. Male players were at slightly increased risk of dental injury compared to controls (OR, 1.15; 95% confidence interval (CI), 1.08–1.23), while no significant difference in dental injuries was seen between female players and controls.

Knee sprains were more common in players than in controls in most age groups, with significantly increased risks seen in all groups except for girls aged  $\leq 12$  years and boys aged 13–15 years (ORs for male players, 1.62–2.86; ORs for female players  $\geq 13$  years, 2.47–7.32). Cruciate ligament injuries were rare in children aged  $\leq 12$  years (1-year incidence 0.05% or less), but the incidences increased steeply from the ages of 13 years in girls and 16 years in boys. Female players aged  $\geq 16$  years were at the greatest risk of this severe injury; the 1-year incidence was approximately 1%, i.e. 7 to 8 times higher than in matched controls. In male players aged  $\geq 16$  years, the 1-year incidence of cruciate ligament injury was approximately 0.5%, i.e. 2 to 3 times higher than in matched controls.

The 1-year incidence of eye injury was  $< 0.5\%$  in all age groups, but compared with controls the risk of such injury was approximately doubled in male players aged  $\geq 13$  years, and significantly increased from the age of 10 years. Even higher ORs were seen for female players aged  $\geq 16$  years, reaching 6.20 (95% CI, 3.39–11.32) in the adult group.

#### 4. Discussion

This population-based nationwide epidemiological study provides initial data on injury incidence in all groups of registered floorball players, compared with that in age- and sex-matched controls. It revealed an increased risk of several types of traumatic injury among floorball players compared with controls. In particular, injuries of the eye and cruciate ligament were notably more common in floorball players than in controls.

Several previous studies have revealed high risks of acute knee injuries, particularly anterior cruciate ligament (ACL) injury, in female participating in sports involving pivoting, jumping, and cutting movements, such as floorball, football, and handball (Hagglund & Walden, 2016; Myklebust, Maehlum, Engebretsen, Strand, & Solheim, 1997; Pasanen et al., 2008; Prodromos, Han, Rogowski, Joyce, & Shi, 2007; Traanaeus et al., 2016). The main finding of the present study is that male and female floorball players in most age groups were at greater risk of cruciate ligament injury compared with controls. Moreover, the risk of this serious injury was seven to eight times greater in female floorball players aged 16–19 and  $\geq 20$  years than in their matched controls. Comparison of our results to those of older studies of floorball players suggests that the incidence of cruciate ligament injury has increased dramatically in recent years, especially among female competitive floorball players (Snellman et al., 2001; Wikstrom & Andersson, 1997). This finding is also confirmed by the results of a study based on injury data from an insurance company, which showed that female floorball players were at greater risk of knee injuries leading to permanent medical impairment, compared to male players (Aman et al., 2016). The majority of these injuries occur without contact with another player (Pasanen et al., 2008). Many athletes sustaining ACL injuries do not return successfully to their pre-injury sport levels, and this injury may lead to the termination of their sports careers despite rehabilitation (Ardern, Webster, Taylor, & Feller, 2011). ACL injuries are also responsible for early-onset osteoarthritis with associated pain, functional limitations, and decreased quality of life in a large number of individuals already in their middle age (Lohmander, Ostenberg, Englund, & Roos, 2004; von Porat, Roos, & Roos, 2004). Therefore, preventive measures, such as effective injury prevention programmes, (Pasanen, Parkkari, Pasanen et al., 2008) should be taken. These measures should target female floorball players, as well as male players, from an early age.

Five previous studies with prospective and retrospective designs have shown that floorball belongs to the highest-risk group of sports in terms of eye injury (Bro & Ghosh, 2016; Drolsum, 1999; Leivo et al., 2015, 2007; Maxen et al., 2011). Similarly, we found that the risk of eye injury was increased in floorball players compared with controls in most age groups, and that the absolute risk was greatest

among males. Due to the higher incidence of eye injury in men overall, the relative risk compared with controls was more pronounced among female players. Bro and Ghosh (Bro & Ghosh, 2016) showed that floorball-related eye injuries seldom lead to chronic vision loss, but found moderate medical consequences and some risk of developing future problems in two-thirds of the patients in their study. In a follow-up study, Leivo et al (Leivo et al., 2015) showed that the incidence of eye injury associated with floorball has declined in Finland due to the enforcement of mandatory use of protective eyewear in younger age groups. Despite this decline, however, the authors reported that floorball remains the leading cause of sports-related eye injury, causing 32% of all sports-related eye trauma (Leivo et al., 2015). The mandatory use of eyewear has been found to minimise the risk of eye injury, (Bro & Ghosh, 2016; Leivo et al., 2015) and the Swedish Floorball Federation implemented this requirement for players aged  $\leq 16$  years in the 2015–2016 season. Previously, many floorball clubs had their own rules regarding mandatory eyewear use for children and teenagers, which may explain the lower incidence of eye injury found in these groups in the present study. The high incidence of eye injury in older age groups indicates a need for rules mandating the use of protective eyewear in all age groups, and for similar recommendations for unofficial floorball practices.

This study has several strengths and limitations. The nationwide study design provides a unique overview of injury incidences and patterns in floorball players of different ages in Sweden, compared with population-based matched controls. Further strengths are the prospective registration of diagnoses, and that all diagnoses in the NPR were set by doctors in specialist care. One limitation is the lack of details about recorded injuries; we could not calculate injury rates by match or training hours, nor determine the causes of injury. Thus, injuries of other causes, including participation in sports other than floorball, were likely included in the analysis. However, such less-specific risk factors should be present in the population-based control groups as well, illustrated for example by the high absolute risk but less-pronounced relative risk of upper extremity fracture in floorball players compared with controls. Another limitation is that the incidence of less severe injuries (e.g. ankle sprains and mild eye trauma) was likely underestimated in this study, as treatment of such injuries may occur in the context of primary health care (which is not covered by the NPR) instead of in hospital.

## 5. Conclusions

This study revealed increased risks of several types of traumatic injury, particularly cruciate ligament and eye injuries, in floorball players compared with controls. These injuries can lead to permanent loss of body function and the termination of players' sports careers. Moreover, they can lead to a sedentary lifestyle, erasing the benefits achieved with participation in sports. Thus, the development and implementation of injury prevention measures, such as specific training programmes and rules regarding the use of protective eyewear, are essential so that floorball players can safely practice their sport. Given the increased risk of injuries seen also in young players, such measures should be applied in all age categories.

### Abbreviations

ACL	anterior cruciate ligament
DHR	Dental Health Register
ICD	International Classification of Diseases
NPR	National Patient Register

### Acknowledgements

This study was supported by grant from Umeå School of Sport Sciences, Umeå University. The authors would also like to thank the Swedish Floorball Federation and the Swedish Floorball Research and Development Center for their support.

### Funding

This work was supported by the Umeå School of Sports Sciences, Umeå Universitet (SE).

### Competing of interests

No potential conflict of interest was reported by the authors

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- Supplemental material**  
Supplemental data for this article can be accessed [here](#).
- Citation information**  
Cite this article as: Injuries in Swedish floorball players: A nationwide matched cohort study, Taru Tervo, Helena Nyström & Anna Nordström, *Cogent Medicine* (2019), 6: 1673087.
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