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# Artificial playing surface increases the injury risk in pivoting indoor sports: a prospective one-season follow-up study in Finnish female floorball

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## ABSTRACT

**Objectives:** To compare the injury risk in pivoting indoor sports between two different surfaces: artificial floors and wooden floors.

**Methods:** Female players (n = 331) from 26 top-level Finnish floorball teams were followed for one competitive season (6 months). All traumatic game related time-loss injuries were recorded. Injury incidences were calculated as the number of injuries per 1000 game hours for both surfaces. Incidence rate ratios (IRRs) were obtained from Poisson regression models.

**Results:** Over the competitive season, 62 traumatic injuries occurred during the games. The injury incidence per 1000 playing hours was 59.9 (95% CI 43.2 to 83.0) on artificial floors and 26.8 (95% CI 18.2 to 39.3) on wooden floors, the adjusted IRR being twofold higher (IRR = 2.1; 95% CI 1.2 to 3.5, p = 0.005) on artificial floors than wooden floors. The risk for non-contact injuries (adjusted IRR = 12.5; 95% CI 2.9 to 54.9, p = 0.001) and severe injuries (adjusted IRR = 3.3; 95% CI 0.9 to 10.9, p = 0.052) was especially high when playing on artificial floors.

**Conclusions:** The study attested that the risk of traumatic injury in pivoting indoor sports is higher when playing on artificial floors than wooden floors. The higher shoe-surface friction on the former surface is likely to explain the higher injury risk.

Floorball is a fast growing indoor team sports that has become very popular in Europe during the last decade. The International Floorball Federation consists of 38 member associations with more than 3700 clubs and more than 250 000 licensed players. The largest member associations are in Sweden, Finland, Switzerland, Czech Republic and Norway.<sup>1</sup> Floorball can be described as hockey played indoors on a court (20×40 m) surrounded by a low board. Each of the opposing teams consists usually of 15–20 players, and five field players and a goalkeeper are on the court at the same time. The players use graphite compound sticks and a light plastic ball. Playing time is 3×20 min. The playing surface can consist of wood (parquet) or artificial materials (plastic covering).

There seem to be two main factors involved in surface-related injuries: hardness of a surface and friction between the sports shoe and surface. Hardness of surface has been associated with overuse injuries in soccer.<sup>2</sup> High friction has been suggested to be an important risk factor of traumatic injuries. Powell and Schootman<sup>3</sup> compared knee injury risk between artificial turf and natural grass in American football. They found

that higher friction between players' shoe and surface on artificial turf slightly increased the risk of knee ligament injuries. Also, higher friction may lead to increased running speed. Field hockey and football players had higher running speeds on artificial surface compared with natural grass.<sup>4–5</sup> Higher playing speeds may increase the risk of collision injuries. On the other hand, if the friction is too low then this may cause slipping-related injuries.

A possible connection between surface and injury risk in indoor team sports has rarely been studied. Olsen and colleagues<sup>6</sup> compared the rate of injury of the anterior cruciate ligament (ACL) of the knee between artificial and wooden floors in team handball and found higher ACL risk for female players on artificial floors. The influence of floor type on injury risk has not been investigated in floorball.

Although growing in popularity, floorball is a sports known to produce lots of injuries, the knee and ankle being the most commonly injured sites.<sup>7–10</sup> Use of artificial surfaces has increased in floorball venues in recent years, and this may partly explain the growing injury rate in this sports.<sup>9–10</sup> The purpose of this prospective study was to compare the incidence of traumatic floorball injuries between two surfaces: artificial floors and wooden floors.

## METHODS

### Participants

Female players (n = 331) were recruited from 26 Finnish top level floorball teams (Elite league and First division). The study arrangements in each participating team confirmed that the coach and contact person of the team agreed to co-operate with the research group. A contact person and coach told the players about the upcoming investigation before the follow-up period started. Final participation was based on the informed consent of each player.

All players who were injury- and symptom-free at the onset of the study completed a questionnaire about background information including anthropometrics, previous injuries, floorball experience and training participation. Table 1 shows the baseline characteristics of players.

### Exposure registration

Each player wrote-up her active floorball game time hours in her personal exercise diary. Exposure time was counted for both floor types: active game hours on artificial floors and on wooden floors.

**Table 1** Characteristics of players (n = 331)

Characteristic	Mean	SD
Age (years)	25.5	5
Height (cm)	166	5
Weight (kg)	61.5	6.5
Floorball experience (years)	7	3
Training per week (h)	5	2

Information on the floor type (parquet or artificial floor) at each game was given by the Finnish Floorball Federation. All teams played on both playing surfaces during the season.

### Injury registration

All injuries were registered with a structured questionnaire. Table 2 gives details about the questionnaire. After each follow-up month, the contact person collected the questionnaires and diaries, and mailed them to the research group. The study physician, in turn, contacted the injured player after every new injury and checked the accuracy and consistency of the completed questionnaire. Additionally, once per month the researchers contacted the teams to check the completeness and coverage of the registration concerning new injuries.

### Injury definitions

An injury was defined as any traumatic injury occurring during a regular Elite league or First division floorball game making the player unable to participate a game or practice session during the following 24 h. Injuries occurring in practices or in other games (eg, European cup, National cup, junior games or tournaments) were excluded. The severity of injury was defined according to Ekstrand and colleagues: minor injury, an injury causing absence from practice of 1–7 days; moderate injury, an injury causing absence from practice of 8–28 days; major injury, an injury causing absence from practice of more than 28 days.<sup>2</sup>

### Drop-outs during the study

Seventeen players (5%) dropped out during the study period: nine stopped playing floorball for an unknown reason and eight because of severe injury. In addition, two new players were included in the study in the middle of the season, immediately after they started to play floorball in the participating teams. Data from these players who dropped out or joined in during the study were included in the analyses for the time they participated.

**Table 2** Injury data collected in the standardised questionnaire

1.	Age
2.	Team name
3.	Division
4.	Date of injury
5.	Name of the venue where the injury occurred
6.	Type of game
7.	Field position when the injury occurred
8.	Type of the floor when the injury occurred (parquet, artificial)
9.	Injury location
10.	Injury type
11.	Cause of the injury (how the injury occurred)
12.	Treatment for the injury
13.	Time-loss from practices/games (how many days)
14.	Diagnosis of the injury (made by a physician)

### Statistical analysis

Analyses were performed with STATA, version 8.2 (2004; Stata Corporation, Lakeway Drive, TX, USA). The injury incidence was expressed as the number of injuries per 1000 h of playing and presented with 95% CIs. The incidence rate ratio (IRR) was defined as the rate of injury on the artificial floors versus the rate of injury on the wooden floors. The unadjusted and adjusted IRRs were obtained from a Poisson model. A p value <0.05 was considered significant. Age-adjustment was used in statistical analyses on the grounds of somewhat different exposure times on the two floor types in different age groups. Other adjustments were done by body mass index, training volume, floorball experience and previous injuries.

## RESULTS

### Exposure and injuries during the season

A total of 230 floorball games were evaluated for floorball injuries sustained while playing on artificial floors or wooden floors. The game exposure on wooden floors was 971 game hours versus 601 game hours on artificial floors. During the season, 51 players sustained 62 traumatic injuries in regular league games. Seven players had two injuries and two players had three injuries during the season. The average age of the injured players was 26 (SD 5) years. The total injury rate was 39.4 (95% CI 30.7 to 50.6) per 1000 game hours.

### Comparison between two floor types

Of the total of 62 injuries, 36 injuries occurred on artificial floors and 26 on wooden floors. The injury incidence per 1000 game hours was 59.9 (95% CI 43.2 to 83.0) on artificial floors versus 26.8 (95% CI 18.2 to 39.3) on wooden floors. Unadjusted IRR of all traumatic injuries was 2.2 (95% CI 1.4 to 3.7, p = 0.002) on artificial floors compared with that on wooden floors.

Unadjusted lower limb IRR was 2.1 (95% CI 1.2 to 3.7, p = 0.012) on artificial floors versus wooden floors. Unadjusted IRR of the most severe injuries was 3.6 times higher (95% CI 1.1 to 11.8, p = 0.032) and of non-contact injuries 13.7 times higher (95% CI 3.2 to 59.4, p < 0.001) on artificial floors. Seven of the knee injuries on artificial floors (7/8) were severe, while on wooden floors three severe knee injuries occurred (3/7). ACL rupture incidence per 1000 game hours was 5.0 (95% CI 1.6 to 5.5) on artificial floors versus 2.1 (95% CI 0.5 to 8.2) on wooden floors. Unadjusted ACL rate ratio was thus 2.4 (95% CI 0.4 to 14.5, p = 0.332) for artificial surfaces.

Table 3 shows the injury incidences and adjusted IRR between the two floor types. The effect of adjustment on the unadjusted IRR values was small.

## DISCUSSION

The aim of the present study was to compare the incidence of traumatic floorball injuries between two surfaces: artificial floors and wooden floors. This study showed, for the first time, that the overall risk of traumatic injury for female floorball players is twofold higher on artificial floors than wooden floors. Moreover, the risk for severe injuries was clearly increased on the artificial surface.

Our study had several strengths. The information was collected prospectively producing good coverage of injuries and high accuracy of exposure times. The study physician interviewed the injured players and checked the accuracy of individual injury information. Each player kept a diary on her personal playing periods for each game, and information on the floor type (parquet or artificial floor) at each game was given by the Finnish Floorball Federation.

**Table 3** Number and incidence (per 1000 playing hours) of injury and adjusted IRR for two floor types

	Artificial floors		Wooden floors		IRR*	p Value
	n	Incidence	n	Incidence		
All traumatic injuries	36	59.9 (43.2 to 83.0)	26	26.8 (18.2 to 39.3)	2.1 (1.2 to 3.5)	0.005
Injury location						
Lower limb	27	44.9 (30.8 to 65.5)	21	21.6 (14.1 to 33.1)	2.0 (1.1 to 3.5)	0.022
Ankle	8	13.3 (6.7 to 26.6)	6	6.2 (2.7 to 13.7)	2.3 (0.8 to 6.6)	0.138
Knee	8	13.3 (6.7 to 26.6)	7	7.2 (3.4 to 15.1)	1.8 (0.6 to 5.1)	0.264
Spine and trunk	3	5.0 (1.6 to 15.4)	4	4.1 (1.5 to 10.9)	1.1 (0.2 to 5.0)	0.919
Head and neck	4	6.7 (2.5 to 7.7)	1	1.0 (0.1 to 7.3)	5.7 (0.6 to 53.6)	0.126
Upper limb	2	3.3 (0.8 to 13.3)	0	–	–	–
Injury type						
Sprain	17	28.3 (17.6 to 45.5)	13	13.4 (7.8 to 23.0)	2.0 (0.9 to 4.1)	0.065
Strain	7	11.6 (5.5 to 24.4)	3	3.1 (1.0 to 9.6)	3.7 (0.9 to 14.6)	0.062
Contusion	8	13.3 (6.7 to 26.6)	8	8.2 (4.1 to 16.4)	1.4 (0.5 to 3.8)	0.526
Fracture	0	–	2	2.1 (0.5 to 8.2)	–	–
Concussion	2	3.3 (0.8 to 13.3)	0	–	–	–
Nerve lesion	1	1.7 (0.2 to 11.8)	0	–	–	–
Laceration	1	1.7 (0.2 to 11.8)	0	–	–	–
Injury situation						
Contact	19	31.6 (20.2 to 49.6)	24	24.7 (16.6 to 36.9)	1.2 (0.6 to 2.2)	0.578
Non-contact	17	28.3 (17.6 to 45.4)	2	2.1 (0.5 to 8.2)	12.5 (2.9 to 54.9)	0.001
Injury severity†						
Minor	16	26.6 (16.3 to 43.4)	17	17.5 (10.9 to 28.2)	1.4 (0.7 to 2.9)	0.315
Moderate	11	18.3 (10.1 to 33.1)	5	5.1 (2.1 to 12.3)	3.3 (1.1 to 9.7)	0.029
Major	9	15.0 (7.8 to 28.8)	4	4.1 (1.5 to 11.0)	3.3 (0.9 to 10.9)	0.052

Injury incidence and adjusted IRRs are given with 95% CIs. IRR is obtained from Poisson model (p value from the z test). Significance level was <0.05.

\*IRR for artificial floors versus wooden floors. The IRR was adjusted for age, body mass index, training volume, floorball experience and previous injuries.

†Injury severity: minor = time-loss 1–7 days, moderate = 8–28 days, major = more than 28 days.

The present study confirmed previous findings suggesting that high friction on artificial surfaces is an important risk factor for traumatic injuries. Powell and Schootman<sup>3</sup> compared the injury rates between natural grass and AstroTurf surfaces in American football. They observed that the risk of knee ligament injuries is slightly increased on artificial turf (incidence density ratio = 1.13; 95% CI 1.00 to 1.27).

Orchard and Powell expanded the findings of Powell and Schootman by comparing injury rates between natural grass and AstroTurf surfaces in various weather conditions.<sup>11</sup> There was a reduced risk of ankle (relative risk = 0.69; 95% CI 0.58 to 0.83) and knee (relative risk = 0.77; 95% CI 0.66 to 0.91) sprains on natural grass compared with artificial turf. They also showed that cold weather is associated with lower knee and ankle injury risk in both natural grass and AstroTurf outdoor stadiums, probably because cold weather produced lower friction.

We compared injury incidences between two different floor types, which clearly differ from each other in the covering materials and friction properties. However, it must be taken into consideration that all the wooden floors and artificial floors are not similar. Freshly varnished and clean wooden floors can have higher friction than their older dusty counterparts. Also, friction between different artificial floors may vary. In general, however, the artificial floors clearly have higher friction than wooden floors.<sup>6</sup>

A second limitation of our study was that we did not have exact information on players' shoes, although it is known that four to five main shoe brands cover the market in floorball, and the players used the same shoes on both floor types. Ideally, each shoe model should be tested on different surfaces for exact information on friction.

Previous studies on surface-related injuries have focused mostly on outdoor sports. However, it is a well known fact that the risk of knee and ankle ligament injuries is especially high in indoor team sports such as basketball, team handball, volleyball and floor-

ball.<sup>9 10 12–15</sup> Today plastic matting surfaces are commonly used in indoor sports venues, but the influence of different surfaces on injury rate in indoor team sports has scarcely been studied. As mentioned, Olsen and colleagues<sup>6</sup> compared ACL injury rate between artificial and wooden floors in team handball and found more than twofold higher ACL risk for female players on artificial floors (odds ratio = 2.35; 95% CI 1.09 to 5.07). Our findings were similar. It seems that the shoe–surface interaction can be a considerable extrinsic risk factor for traumatic injury of lower limbs.

In this context it is, however, important to keep in mind that injuries in pivoting sports, particularly of the knee and ankle, are

### What is already known on this topic

- ▶ Floorball is a sport that often results in traumatic injuries, the knee and ankle being the most commonly injured sites.
- ▶ High friction has been suggested to be an important risk factor of traumatic injuries in pivoting sports such as American football or team handball.
- ▶ Use of artificial surfaces has increased in floorball venues in recent years. However, the influence of floor type on injury risk has not been investigated in floorball.

### What this study adds

- ▶ The incidence of traumatic floorball injuries is two times higher on artificial floors than on wooden floors.
- ▶ The risks for non-contact and severe injuries were 12-fold and threefold higher, respectively.

seldom a result of any single risk factor. Greater and more precise information on sports-specific risk factors, including measurements of friction characteristics and injury mechanisms, are needed for effective injury prevention.

## CONCLUSION

The present study showed that the risk of traumatic injury among female floorball players is twofold higher when playing on artificial than wooden floors. Moreover, the rate of severe injuries was especially high on artificial floors. To control the increasing burden of injuries in pivoting sports, the role of shoe-surface friction in injury aetiology should be better acknowledged.

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**Competing interests:** None declared.

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