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ORIGINAL ARTICLE

Sports-based distribution of facial fractures – findings from a four-season country

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ABSTRACT

Objective: The aim of this study was to elucidate the relationship between injury mechanisms and sports-related facial fractures, and to evaluate the changes in incidence rates of facial fractures sustained in sports-related events in a 30-year period.

Material and methods: This retrospective cohort study included all patients sports-related facial fractures admitted to a tertiary trauma centre during 2013–2018. Specific fracture types, sports, injury mechanisms as well as patient- and injury related variables are presented. The results underwent evaluated statistically with logistic regression analysis.

Results: Facial fractures occurred most frequently while playing ice hockey and football. Unilateral zygomatic-maxillary-orbital and isolated mandibular fractures accounted for 74.2% of all fracture types. In total, 99 patients (46.5%) required surgical intervention for their facial injuries. About 12.7% of patients sustained associated injuries in addition to facial fractures. Overall, the number of sports-related facial fractures has increased during the last three decades mostly due to the surging rates of ice hockey- and football-related facial fractures.

Conclusions: Sport-related facial fractures have markedly increased in different sports disciplines during the past decades. The use of safety gear to protect the facial area should be enforced particularly in ice hockey.

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Introduction

Injuries to the maxillofacial region are a known and increasing risk related to different sports and recreational activities [1–3]. Due to particular traits of some sports, persons partaking in these activities may be subjected to multiple different modes of force transmission resulting in different hard and soft tissue trauma. Especially patients with injuries sustained from team sports involving physical contact or from different forms of martial arts are a common sight in emergency departments. The rising prevalence of sports-related injuries is most likely due to the popularity of specific sports increasing globally [2,4].

The incidences of sports-related facial fractures have been reported to range from 4.1% to 21.7% [1,2,5–9]. Traits of sports-related trauma incidents are often unique and multifactorial. Additionally, a strong relationship exists between specific sports, the geographical locations where they are played and the characteristics of sustained maxillofacial injuries [5,8]. For example, most sports-related injuries in Central and Southern Europe are seen in football, baseball-related injuries are highly represented in Japan, and in New Zealand injuries are mostly associated with rugby [1,2,5,10].

In addition to the traits of specific sports, the mechanism of injury is important. Collisions with other players and impact against sports equipment, including balls and pucks, are the most frequent causes of maxillofacial injuries [9]. These injury mechanisms are often seen in accidents related to team sports that involve physical contact and mobile playing equipment. The lower and middle thirds of the facial skeleton are the most susceptible to trauma [1,9] and this is at least partly due to the lack of facial protection used or offered by standard safety equipment.

Although improved protective gear has decreased sports-related facial fractures in some recreational activities, there has been an increase in facial fractures in certain contact-driven team sports, placing considerable demands on maxillofacial trauma centres treating these types of injuries. Therefore, it is important to investigate and identify the predictors for sports-related facial fractures from an injury mechanism standpoint to develop effective countermeasures. The

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aim of this study was to clarify occurrence rates and trends of sports-related facial fractures in a four-season country. Additionally, we compared our findings with a previous publication from our institution with a similar study setup [11]. Our hypothesis was that incidence rates of facial fractures resulting from sport injuries have increased in recent decades.

Methods

Study design

All facial fracture patients admitted to a tertiary trauma centre (Trauma Unit of Helsinki University Hospital, Helsinki, Finland) between 1 January 2013 and 31 December 2018 were evaluated retrospectively. Patients with any type of facial fracture due to a sports-related injury were included in the study.

Patients who sustained fractures due to bicycle-, skateboard-, or similar trauma were excluded from the study since it could not be reliably determined which of the accidents happened during transition instead of engagement in a recreational activity. All fractures were diagnosed based on clinical examination and radiographic imaging.

Occurrence of different facial fractures and corresponding sport activities were reported. Patient and injury-related variables and specific fracture types were presented and associations between these and specific injury mechanisms were analyzed.

Sport injury trends during a 30-year period were evaluated by comparing our results with those published in 1988 from the same institution by Sane et al. [11].

Study variables

Patient and injury-related variables were sex, age, need for surgical intervention for facial fracture and presence of any associated injury (AI). AIs were defined as head injury (including cranial fractures and traumatic brain injuries), injury of extremities (including fractures and joint dislocations of the upper and lower extremities), ocular injuries (affecting the bulbus and optic nerve), torso injuries (thoracic, abdominal and pelvic injuries) and neck injuries (cervical spine injuries and blunt cerebrovascular injuries)

Facial fractures were classified as isolated mandibular, isolated zygomatico-maxillary-orbital (ZMO, defined as isolated maxillary, isolated zygomatic, isolated orbital fractures as well as any unilateral combination of the aforementioned), isolated nasal, combined midfacial, combinations of different facial thirds and other fracture types.

Sport activities were defined by their names. 'Baseball' included both traditional baseball as well as the Finnish variant. 'Skiing' included downhill and cross-country skiing. 'Martial arts' included all forms and styles of self-defence and combat sports. 'Gymnastics and similar' included injuries related to gymnastics, cheerleading and dancing. 'Other' sports included beach volley, bouldering, ice skating, paragliding and iceboating.

Injuries sustained from these sports were then classified according to specific injury mechanism as impact against environment (e.g. falling down), high-energy impact against environment (e.g. high-velocity falls, falling off a horse, collision with a tree or person during downhill skiing), impact against player (e.g. tackled or struck by another player), impact against equipment (e.g. puck or ball) and struck by horse (including kicks and headbutts).

Statistical analyses

For categorical variables, Pearson's Chi-square test was used unless cell had five or less observations, in which case Fisher's exact test was applied. Median and interquartile range were analyzed for age, as it was not normally distributed. Bivariate logistic regression or exact logistic regression was used to determine the associations between fracture types and each mechanism of injury as well as the explanatory variables. Odds ratios (ORs) were reported with their respective 95% confidence intervals (CI) and statistical significance was set at 0.05. Data analysis was performed using Stata version 16 (StataCorp, College Station, TX).

Ethical considerations

The study was approved by the Internal Review Board of the Head and Neck Centre, Helsinki University Hospital, Helsinki, Finland (HUS/356/2017 and HUS/54/2019).

Results

Of the 2919 facial fracture patients, 213 (7.3%) sustained their injuries in sports-related accidents and were included in the final analyses. Males were over-represented in the study population as the sex ratio between males and females was approximately 3:1 (Table 1). The median age was 27.7 years for males and 28.6 years for females. Seasonal variation of fracture incidence rates is presented in Figure 1. Sports-related facial fractures mostly took place between February and April during this 6-year time period.

Facial fractures occurred most often while playing ice hockey ($n = 55$, 25.8% of all patients) and injuries in this sport were almost entirely confined to males (98.2%, $p < .001$). Football ($n = 44$, 20.7%), horseback riding ($n = 34$, 16.0%) and martial arts ($n = 21$, 9.9%) were also highly represented. In 51.5% of cases, males sustained their fractures due to collision with another player, whereas females were most likely to be injured due to high-energy impact against the environment (41.7%). In total, 99 patients (46.5%) required surgical intervention for their facial injuries. AIs were diagnosed in 12.7% of all patients.

The most frequent fracture type in sports-related facial fractures was a unilateral-ZMO fracture (39.9%), mostly seen in football-related injuries (Table 2). The second most frequent fracture type, mandibular fracture (34.3%), mostly occurred while playing ice hockey. Patients who sustained fractures in multiple facial thirds accounted for only 4.2% of all cases.

Table 1. Descriptive statistics for patients sustaining sports-related facial fractures.

	Male (%)	% of *n*	Female (%)	% of *n*	Total	*p* Value
Total	165	77.5	48	22.5	213	
Median age (interquartile range)	27.68 (20.73, 36.43)		28.64 (18.79, 42.98)		27.68 (20.42, 37.68)	.715
Sport						
Ice hockey	54 (32.7)	98.2	1 (2.1)	1.8	55	<.001
Football	40 (24.2)	90.9	4 (8.3)	9.1	44	.015
Horseback riding	3 (1.8)	8.8	31 (64.6)	9.12	34	<.001
Martial arts	21 (12.7)	100.0	0 (0.0)	0.0	21	.005
Baseball	7 (4.2)	58.3	5 (10.4)	41.7	12	.147
Floorball	7 (4.2)	87.5	1 (2.1)	12.5	8	.687
Skiing	5 (3.0)	71.4	2 (4.2)	28.6	7	.657
Gymnastics and similar	4 (2.4)	57.1	3 (6.3)	24.9	7	.191
Basketball	5 (3.0)	100.0	0 (0.0)	0.0	5	.590
Tennis and badminton	4 (2.4)	100.0	0 (0.0)	0.0	4	.577
Rugby and American football	3 (1.8)	100.0	0 (0.0)	0.0	3	1.000
Powerlifting						
Field hockey	2 (1.2)	100.0	0 (0.0)	0.0	2	1.000
Cricket	2 (1.2)	100.0	0 (0.0)	0.0	2	1.000
Nordic walking	2 (1.2)	100.0	0 (0.0)	0.0	2	1.000
Other	1 (0.6)	50.0	1 (2.1)	50.0	2	.410
	5 (3.0)	100.0	0 (0.0)	0.0	5	.590
Injury mechanism						
Impact against environment	10 (6.1)	90.9	1 (2.1)	9.1	11	.462
High-energy impact against environment	9 (5.5)	31.0	20 (41.7)	69.0	29	<.001
Impact against player	85 (51.5)	91.4	8 (16.7)	8.6	93	<.001
Impact against equipment	58 (35.2)	90.6	6 (12.5)	9.4	64	.003
Struck by horse	3 (1.8)	18.8	13 (27.1)	81.3	16	<.001
Surgical intervention						
No	89 (53.9)	78.1	25 (52.1)	21.9	114	
Yes	76 (46.1)	76.8	23 (47.9)	23.2	99	.820
Associated injury						.004
No	150 (90.9)	80.6	36 (75.0)	19.4	186	
Yes	15 (9.1)	55.6	12 (25.0)	44.4	27	
Total injuries	17	54.8	14	45.2	31	
Head injury	8	80	2	20	10	1.000
Extremities	4	44.4	5	55.6	9	.029
Ocular	4	50	4	50	8	.079
Torso	1	33.3	2	66.7	3	.128
Neck injury	0	0.0	1	100.0	1	.225

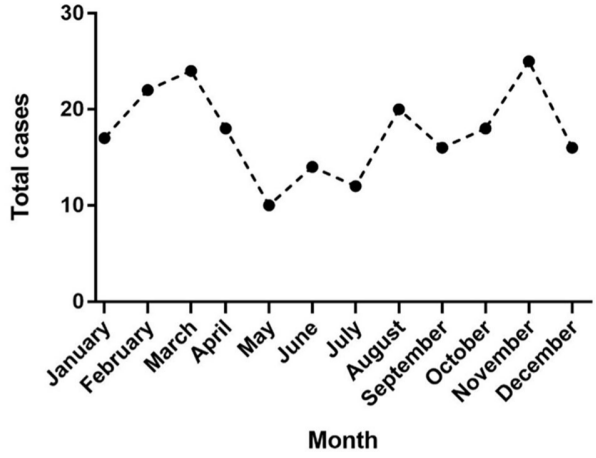

Figure 1. Distribution of sports-related facial fractures during 2013–2018. Most of the facial fractures took place during the months of February, March and November. Indoor sporting facilities may inversely affect the relation between specific sports and the season in which they are usually played.

Further analyses concerning the relationship between injury mechanisms and demographic variables and other clinically relevant parameters are shown in Table 3. Males were at high risk of sustaining their injuries in team sports (impact against player OR 5.31, CI (95%) 2.34, 12.04, $p < .001$ and impact against equipment, OR 3.79, CI (95%) 1.52, 9.46, $p = .004$). Patients sustaining their injuries upon impact with other players were less likely to require surgical intervention (OR 0.53, CI (95%) 0.30, 0.92, $p = .023$) than other injury mechanism types. High-energy impact against the environment was a significant risk factor for patients to sustain AI (OR 4.15, CI (95%) 1.65, 10.46, $p = .003$).

To further assess the cause of each facial fracture type, the relationship between specific fracture types and injury mechanisms were analyzed (Table 4). Mandible fractures were strongly associated with impact against equipment (OR 2.39, CI 1.31, 4.39, $p = .005$). Patients were susceptible to nasal fractures when subjected to impact against other players (OR 4.27, CI 1.24, 18.81, $p = .018$). A high risk of fractures in combinations of facial thirds was noted in patients struck by a horse (OR 7.21, CI, 1.05, 38.77, $p = .045$).

Trends in sports-related facial fractures between two study periods 30 years apart are presented in Figure 2. Substantial increases in football- and ice hockey-related facial fractures have occurred.

Discussion

Our results reinforce previously reported findings of sports-related facial fractures, but also bring novel insights into the associations between injury mechanisms and other clinically relevant variables. In total, 7.3% of all facial fractures during

Table 2. Relationship between different sports and sustained facial fractures.

	All facial fractures	Unilateral ZMO	Mandible	Nasal	Combined mid-facial	Combination of facial thirds	Other
Ice hockey	55 (25.8%)	16 (18.8%)	31 (42.5%)	2 (12.5%)	3 (13.0%)	1 (11.1%)	2 (28.6%)
Football	44 (20.7%)	22 (25.9%)	11 (15.1%)	5 (31.3%)	5 (21.7%)	1 (11.1%)	0 (0.0%)
Horseback riding	34 (16.0%)	13 (15.3%)	8 (11.0%)	2 (12.5%)	4 (17.4%)	5 (55.6%)	2 (28.6%)
Martial arts	21 (9.9%)	9 (10.6%)	7 (9.6%)	3 (18.8%)	2 (8.7%)	0 (0.0%)	0 (0.0%)
Baseball	12 (5.6%)	5 (5.9%)	2 (2.7%)	1 (6.3%)	2 (8.7%)	0 (0.0%)	2 (28.6%)
Floorball	8 (3.8%)	3 (3.5%)	5 (6.8%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Skiing	7 (3.3%)	2 (2.4%)	2 (2.7%)	0 (0.0%)	2 (8.7%)	1 (11.1%)	0 (0.0%)
Gymnastics	7 (3.3%)	3 (3.5%)	2 (2.7%)	1 (6.3%)	0 (0.0%)	1 (11.1%)	0 (0.0%)
Basketball	5 (2.3%)	1 (1.2%)	2 (2.7%)	1 (6.3%)	0 (0.0%)	0 (0.0%)	1 (14.3%)
Tennis/badminton	4 (1.9%)	3 (3.5%)	0 (0.0%)	0 (0.0%)	1 (4.3%)	0 (0.0%)	0 (0.0%)
Rugby/American football	3 (1.4%)	1 (1.2%)	0 (0.0%)	1 (6.3%)	1 (4.3%)	0 (0.0%)	0 (0.0%)
Power-lifting	2 (0.9%)	1 (1.2%)	1 (1.4%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Field hockey	2 (0.9%)	2 (2.4%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Cricket	2 (0.9%)	2 (2.4%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Nordic walking	2 (0.9%)	0 (0.0%)	1 (1.4%)	0 (0.0%)	1 (4.3%)	0 (0.0%)	0 (0.0%)
Other	5 (2.3%)	2 (2.4%)	1 (1.4%)	0 (0.0%)	2 (8.7%)	0 (0.0%)	0 (0.0%)
Total	213	85	73	16	23	9	7

Table 3. Relationship between injury mechanisms and patient variables.

	Impact against environment	Impact against player	Impact against equipment	Struck by horse	High-energy impact against environment
Sex (ref. female)	OR: 3.02 CI (95%): 0.41, 134.4 $p = .491$	OR: 5.31 CI (95%): 2.34, 12.04 **$p < .001$**	OR: 3.79 CI (95%): 1.52, 9.46 **$p = .004$**	OR: 0.05 CI (95%): 0.01, 0.20 **$p < .001$**	OR: 0.08 CI (95%): 0.03, 0.20 **$p < .001$**
Age	OR: 1.05 CI (95%): 1.02, 1.09 **$p = .005$**	OR: 0.98 CI (95%): 0.96, 1.00 **$p = .022$**	OR: 0.98 CI (95%): 0.96, 1.00 $p = .055$	OR: 1.02 CI (95%): 0.98, 1.05 $p = .359$	OR: 1.04 CI (95%): 1.02, 1.07 **$p = .002$**
Surgical intervention	OR: 1.40 CI (95%): 0.34, 6.02 $p = .806$	OR: 0.53 CI (95%): 0.30, 0.92 **$p = .023$**	OR: 1.46 CI (95%): 0.81, 2.64 $p = .203$	OR: 0.89 CI (95%): 0.32, 2.48 $p = .820$	OR: 1.76 CI (95%): 0.80, 3.90 $p = .162$
Associated injuries	OR: 1.57 CI (95%): 0.16, 8.23 $p = .836$	OR: 0.25 CI (95%): 0.07, 0.73 **$p = .007$**	OR: 0.63 CI (95%): 0.24, 1.64 $p = .346$	OR: 3.58 CI (95%): 0.89, 12.54 $p = .073$	OR: 4.15 CI (95%): 1.65, 10.46 **$p = .003$**

Statistically significant p-values $< .05$ are bolded.

Table 4. Relationship between injury mechanism and sustained facial fractures.

	Impact against environment	Impact against player	Impact against equipment	Struck by horse	High-energy impact against environment
Unilateral ZMO	OR: 1.27 CI (95%): 0.30, 5.18 $p = .989$	OR: 1.26 CI (95%): 0.72, 2.19 $p = .416$	OR: 0.87 CI (95%): 0.47, 1.58 $p = .638$	OR: 0.67 CI (95%) 0.17, 2.18 $p = .649$	OR: 0.91 CI (95%): 0.41, 2.03 $p = .815$
Mandible	OR: 0.71 CI (95%): 0.12, 3.07 $p = .886$	OR 0.72 CI (95%): 0.40, 1.28 $p = .260$	OR: 2.39 CI (95%): 1.31, 4.39 **$p = .005$**	OR: 0.42 CI (95%) 0.07, 1.60 $p = .275$	OR: 0.70 CI (95%): 0.29., 1.66 $p = .416$
Nasal	OR: 1.25 CI (95): 0.03, 9.90 $p = 1.000$	OR 4.27 CI (95%): 1.24, 18.81 **$p = .018$**	OR: 0.142 CI (95%): 0.003, 0.97 **$p = .044$**	OR 0.81 CI (95%) 0.02, 6.02 $p = 1.000$	OR: 0.40 CI (95%): 0.01, 2.83 $p = .656$
Combined midfacial	OR: 1.91 CI (95%): 0.19, 10.15 $p = .675$	OR: 0.81 CI (95%): 0.33, 1.97 $p = .643$	OR: 0.46 CI (95%): 0.11, 1.46 $p = .241$	OR 2.03 CI (95%) 0.34, 8.34 $p = .482$	OR: 0.91 CI (95%): 0.51, 6.03 $p = .369$
Combination of facial thirds	OR: 1.45 CI (95%): 0.0, 10.23 $p = 1.000$	OR: 0.36 CI (95%): 0.04, 1.93 $p = .328$	OR: 0.28 CI (95%): 0.01, 2.17 $p = .378$	OR: 7.21 CI (95%): 1.05, 38.77 **$p = .045$**	OR: 0.39 CI (95%): 0.52, 17.10 $p = .217$
Other	OR: 1,91 CI (95%): 0.0, 14.00 $p = 1.000$	OR: 0.51 CI (95%): 0.05, 3.18 $p = .680$	OR: 1.78 CI (95%): 0.25, 10.85 $p = .706$	OR: 2.11 CI (95%): 0.04, 19.30 $p = .852$	OR: 1.06 CI (95%): 0.02, 9.25 $p = 1.000$

Statistically significant p-values $< .05$ are bolded.

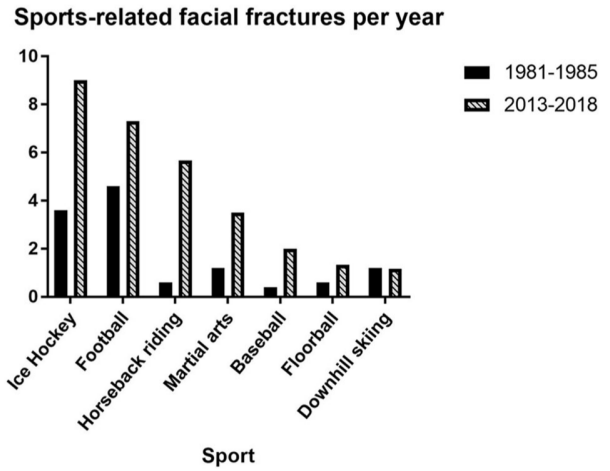

Figure 2. Sports-related facial fractures per year. During the past 30 years, facial fractures that occurred during ice-hockey and football have risen significantly. Additionally, the number of facial fractures in general has also increased substantially.

the study period were sports-related. Our hypothesis was confirmed as facial fractures occurred much more frequently than in the previous study from the same institution. Males were over-represented in our study and facial fractures occurred most frequently while playing ice hockey. Unilateral ZMO and isolated mandibular fractures accounted for 74.2% of all fracture types. Overall, the number of sports-related facial fractures has increased during the last three decades.

The largest proportion of facial fractures was sustained while playing ice hockey, with these injuries accounting for over one quarter (25.6%) of all cases. The proportion of ice hockey-related injuries has been reported to be lower elsewhere [7,10], and, as stated earlier, is most likely due to the varying popularity of different sports in different countries. However, our finding is in concordance with a recent report stating that professional ice hockey players had the highest injury rate of craniomaxillofacial injuries relative to other professional athletes in the United States [12]. A recent article by Cimba et al. highlighted the benefits of implementing visor-styled protective gear on upper facial injuries in National Hockey League (NHL) players, but this study did not include discussion about the possible benefits of masks covering the whole facial region [13]. In our study, 42.5% of fractures sustained during ice hockey were isolated mandibular fractures. Another widely encountered issue, although slightly outside the scope of this study, is the alarming prevalence rates of dentoalveolar injuries in ice hockey players [14,15]. Therefore, the use of facial shields and cage masks protecting the entire facial area is highly recommended, and has been for decades [16].

The second highest proportion of facial fractures occurred while playing football, a sport where players in Europe have no protective gear shielding the head and face. A specific and typical injury for this patient group is force transmission induced by head-butting or being struck with an elbow when multiple players are attempting to take possession of a descending ball. Our results highlight that especially the nasal region is prone to being fractured upon impact with other players. Similarly, a German study by Elhammali and colleagues reported that almost 60% of all sports-related fractures took place while playing football and 67.3% of these fractures were located in the middle third of the facial skeleton [5].

Concerning the other sports on our list, facial fractures in patients partaking in martial arts were notably high. Martial arts comprise a large number of disciplines with an emphasis on both striking and submission, and virtually all of these combat styles target the head and neck region in some way [17,18]. A recent review summarizing the current literature on martial arts-related injuries stated that an important subject of discussion was the neurological injuries associated within this specific patient population [19]. Also noteworthy is the relatively high fracture rates sustained while playing baseball. In this sport where the safety gear used is dependent on the player's position, a distinctive feature is the high-velocity movement of baseballs due to throws and hits [10]. The short distance between the pitcher and the batter especially increases the risk of being hit by a ball and predisposes players to different kinds of facial injuries.

Our institution published findings with a similar study setup over 30 years ago [11]. During that 5-year study period, 80 patients sustained sports-related facial fractures (5.6% of all patients). Compared with those results, annual ice hockey- and football-related facial fractures have risen by 155.5% and 58.7%, respectively. In addition, the occurrence rates for fractures sustained in other sports have also significantly increased. This raises serious concern over the efficacy of and compliance with sports-related safety measures.

Although sports predispose to injuries to all parts of the body, the incidence of AI among facial fracture patients is reported to be relatively low, ranging between 4.2% and 7.2% [2,7,10]. This is partly explained by the notion that most sports-related maxillofacial injuries are the result of singular, isolated modes of force transmission, such as being tackled by another player or being hit in the facial area with a puck. This is also reflected in the observation that sports-related maxillofacial fractures have shown lower Facial Injury Severity Scale scores than to other aetiologies [2]. In our study, injuries confined to the extremities followed by head injuries were the most frequent AIs. AIs were most likely to occur in patients who sustained their injuries *via* high-energy impact against the environment (OR 4.15, CI (95%) 1.65,10.46, $p = .003$).

The number of active participants in different sports varies according to the time of year in a four-season country. In our present study, the highest occurrence rates for sports-related facial fractures were detected in March and November. However, indoor sporting facilities allow many sports to be played year-round and this may inversely affect the relation between specific sports and the season in which they are usually played.

The retrospective study design is the main limitation of our study, especially as we were unable to distinguish properly classify bicycle-related injuries. In addition, the total of number of fractures sustained in most of these sports remains small, and thus, no specific recommendations for these specific populations can be made.

In conclusion, during the past 30 years, sports-related facial fractures have markedly increased in different sports disciplines. The use of safety gear to protect the facial area should be enforced particularly in ice hockey.

Disclosure statement

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