

Concussed athletes are more prone to injury both before and after their index concussion: a data base analysis of 699 concussed contact sports athletes

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ABSTRACT

Background: Ice hockey and football players suffering concussions might have an increased risk for injuries afterwards. We aimed to investigate if concussions predisposed athletes for subsequent sport injuries.

Methods: Patient data were obtained from a data base established at the University Hospital in Umea, Sweden. Athletes who had suffered a concussion were included if they had been aged between 15 and 35 years of age, and played ice hockey, football (soccer), floorball and handball. They were studied in terms of all new or previous injuries during 24 months before and after their concussion. Results were compared with a control group of athletes from the same four sports with an ankle injury.

Results: Athletes with a concussion were more likely to sustain injuries compared with the control group, both before (OR 1.98. 95% CI 1.45 to 2.72) and after the concussion (OR 1.72. 95% CI 1.26 to 2.37). No increase in frequency of injury was found after a concussion compared with before. This was true for athletes in all four sports and for both sexes.

Conclusions: This study indicates that athletes sustaining a concussion may have a more aggressive or risk-taking style of play than their counterparts. Our data do not suggest that a concussion injury, per se, leads to subsequent injuries.

Concussions are a well-documented risk when participating in contact sports, like ice hockey, American football, rugby and soccer.¹ Efforts to decrease the risks have resulted in changes and additions of rules (such as 'checking to the head' in ice hockey) and improved safety equipment, yet players keep sustaining concussions.² Helmets are mandatory in American football and ice hockey, but in spite of this, a high concussion rate per athlete exposure has been reported.² Concussion can occur after a direct blow to the head or after a body trauma where impulsive forces are transmitted to the brain.^{3 4} Helmets can protect the

What are the new findings?

- Athletes who have sustained a concussion seem to be more injury prone.
- Concussed athletes have more injuries both before and after they sustained the concussion.
- The increased injury risk does not seem to be dependent on sport or sex.

How might it impact on clinical practice in the near future?

Athletes with concussion should be more thoroughly evaluated, especially concerning their style of play.

brain from a direct blow but do not protect against impulsive, often rotational forces, which often occur at accidents causing concussions in ice hockey.⁵

Already in 1993, Ingersoll reported that concussion and closed-head injury result in cognitive and balance defects.^{6 7} Several authors have since verified this.^{8 9–12} Long and short-term consequences after multiple mild traumatic head injury can also involve depression, Alzheimer's disease, Parkinson's disease and chronic traumatic encephalopathy (CTE).^{13–17} Whether concussions can increase the athlete's general risk for injury is unclear.

Preliminary results by Nyberg *et al*¹⁸ showed that professional ice hockey players in the Swedish Hockey League who sustain a concussion run a higher risk of sustaining another serious injury (resulting in an absence of >28 days) during the first 21 days after return to play after the concussion. Recently, Nordström *et al*¹⁹ showed, that players run a higher risk for injury during the 1 year after a concussion in a highly



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selected cohort of elite football players participating in the UEFA Champions League. In their analysis, they adjusted for the fact that players who subsequently suffered from a concussion were generally more injury prone than those with other injuries. One possible explanation to this finding might be that a concussion causes altered postural dynamics, and a negative effect on balance,^{12–20} which may result in an increased risk for injury. Some studies have shown that these balance effects are long standing.^{21–22} It has also been shown that symptom-free individuals may still have measurable neuropsychological impairment after a concussion, indicating a long-standing effect of a concussion.^{23–24}

The consequences of a concussion remain poorly understood. One important question is whether the findings in elite sport apply to physically active people in general. A less selected group of athletes may have less motivation for early and possibly risky return to full activity. In Nordström's¹⁹ study, athletes with a concussion returned earlier to full activity, including matches, than those with other injuries. To address the question of risk for a subsequent injury after concussions during sport, we studied a large data base of patients who had presented at an emergency department with concussion.

METHODS

Patient data was collected from a data base (Umea Injury Data Base) established in 1985 at the Emergency Department of the University Hospital in Umea. The hospital is the only university hospital in northern Sweden (population 950 000), and the primary hospital for about 145 000 inhabitants. It is also the only hospital within a 120 km radius. Thus, all injuries that occurred in this district were cared for at the University Hospital's emergency department, except simple minor injuries, which were cared for by general practitioners. Thus, the data base includes all significant injuries in the area. On arrival at the emergency department, the injured person, or a relative, was given a questionnaire about the circumstances of the injury. The questionnaires also contain written information about the purpose of registration, and by filling it out they gave their consent to participate. If needed, when data was implausible or missing, it may be corrected or completed, using medical journals as well as police or ambulance reports. A medical doctor sets all diagnoses in the data base.

The register is part of the European Injury Data Base, former European Home and Leisure Accident Surveillance System.

Inclusion criteria

The first step was to select four contact sports; ice hockey, football (soccer), handball and floorball. After that, concussions in athletes between 15 and 35 years of age in these four sports between 1995 and 2009 were collected from the data base. These concussions were classified as index injuries. In athletes with more than one concussion, the first one was the index injury. Age restriction was implemented due to the fact that at the age of 15 years, checking has been introduced in ice hockey; a larger playing field is used in football (soccer), and a more organised play can be expected in all four sports. An upper age restriction was used to sort out individuals who might have a pre-existing condition that would increase the risk of injury. Besides, being 35 years old is also the age when one is considered a veteran in many sports.

Finally, additional injuries were collected from an observation time of 24 months before and after the index injury. This means that the study involves injuries from 1993 to 2011. The clinical end points of the study were injuries that had occurred during the 24-month period before and after the index injury. A control group of athletes with an ankle sprain, but no concussion, was sampled from the same data base, during the same time period, in the same age span, and in the same four sports, was used for comparison. Consequently, they were analysed in the same manner, with the ankle distortion being the index injury.

Statistical methods and ethics

The athletes were divided into groups; those with injuries before/after their index injury and those without. The number of athletes with injuries during 24 months before/after the index injury was used as primary end point. These numbers were used to calculate an OR to investigate the distribution of athletes who suffered injuries after their index injury compared with before, and also if there was any difference between the concussion group and the control group. A χ^2 test was used to investigate if the injury pattern differed when grouping based on sex or sport was done. Standard statistics were calculated in Excel and SPSS V.17.

RESULTS

For the period 1995–2009, the data base included 4961 concussions (2691 men and 2270 women, all ≥ 15 years of age). Of these, 699 (14%; 420 men and 279 women) occurred during the participation in different athletics and sports, and 281 (40%; 206 men and 75 women) met

Table 1 Number of athletes (per cent of total in the group) with either a concussion or an ankle injury (control group) in the four different sports

	Ice hockey (%)	Soccer (%)	Floorball (%)	Handball (%)	Total
Concussion	71 (25)	158 (56)	45 (16)	7 (3)	281
Control	43 (3)	773 (63)	400 (32)	44 (4)	1259

Table 2 The odds and OR for an athlete to be injured 24 months before and after an index injury in the concussion and control groups

Group	Time	Total injuries (n)	Uninjured individuals (n)	Injured individuals (n)	Number of individuals with 1 or 2 or more injuries before or after the concussion	
					n=1	n>1
Concussion (n=281)	Before	103	211	70 Odds 0.33 OR 1.98	48	22 Odds 0.46 OR 2.39
	After	93	215	66 Odds 0.31 OR 1.72	44	22 Odds 0.50 OR 2.14
Control (ankle injury) (n=1259)	Before	214	1079	180 Odds 0.17	151	29 Odds 0.19
	After	236	1069	190 Odds 0.18	154	36 Odds 0.23

Odds and OR are calculated by comparison with the number of athletes without injury during the same period of time. The pattern of a higher risk for injury both before and after concussion was seen in all four sports (table 3).

the inclusions criteria. The mean age was 20.0 \pm 4.7 years.

The control group consisted of 1259 athletes, 885 men and 374 women. The mean age was of 21.4 \pm 5.1 years.

The distribution of sports between the concussion and control groups is shown in table 1. Ankle injuries occurred significantly less often in ice hockey players ($p=0.000$).

Table 2 shows the number of injuries and athletes with or without injury 24 months before and after the index injury. There was a higher risk for injury both before and after the index injury among athletes with concussions compared with the control group. The OR for an injury was 1.98 (95% CI 1.45 to 2.72) before and 1.72 (95% CI 1.26 to 2.37) after. There were also significantly more athletes who suffered two injuries or more, both before and after the concussion, compared with the control group (before OR 2.39 (95% CI 1.26 to 4.54) and after OR 2.14 (95% CI 1.14 to 4.01)). No significant increase could be seen in the number of injured individuals after the concussion compared with before the concussion (OR 0.925 (95% CI 0.63 to 1.36)).

DISCUSSION

We found that athletes, regardless of sport or sex, who sustain a concussion, had a higher risk of injury afterwards, but this risk was not higher than it was before the concussion. This means that this study did not support previous studies indicating that a concussion increases the risk for new injuries. It rather seems as if concussed athletes have a 'risk behaviour' resulting in a higher risk for injury. Possibly, a concussion should be noted as an indicator of a generally increased risk for injury in sports. Before this can be stated, more studies are needed.

Our results are both in accordance and opposite to the study by Nordström *et al.*¹⁹ Like Nordström *et al* we found that athletes with concussions were more injury prone in general, than those with other injuries, but we did not find any additional increase in risk for injury during the two following years that were included in our study. Our study design was different compared with that of Nordström *et al*, but the most important difference is the setting. We only included injuries at an emergency department, and there was no selection of athletes

Table 3 Injuries before and after index injury in the concussion and the control groups divided depending on sport participation

		Index injury	Injury before index injury	Injury after index injury	Injury before per index case	Injury after per index case
Ice hockey	Concussion	71	33	32	0.46	0.45
	Control	42	10	14	0.24	0.33
Football (soccer)	Concussion	158	57	48	0.36	0.3
	Control	773	149	160	0.19	0.21
Floorball	Concussion	45	10	9	0.22	0.2
	Control	400	44	51	0.11	0.13
Handball	Concussion	7	3	4	0.43	0.57
	Control	44	11	11	0.25	0.25

In addition, a significantly higher risk for injury, both before and after concussion, compared with ankle injury (control group), was found both in men ($p=0.001$ and 0.007) and women ($p=0.002$ and 0.016 ; table 4).

Table 4 Women and men with or without another injury before or after concussion and ankle injury (control)

	Concussion	Control	p Value
Women			
With injury before	20	48	0.002
No injury before	55	326	
With injury after	19	53	0.016
No injury after	56	321	
Men			
With injury before	50	132	0.001
No injury before	156	753	
With injury after	48	137	0.007
No injury after	158	748	

depending on their level of participation, elite or at a lower level.

A higher proportion of the athletes with a concussion in our study participated in ice hockey. This is a selection bias related to the design of the study. However, the most likely explanation is not that ice hockey is more attractive for 'high-risk' individuals, but the simple fact that ankle injuries are rare in ice hockey as the ankle is partly protected by the skate. Moreover, the fact that athletes with concussions had more injuries both before and after was true not only in ice hockey but in all four contact sports.

Strength and limitations

A strength of the Umeå Injury Data Base is that a medical doctor examines all injuries and makes all the diagnoses. For concussions, the importance that the diagnosis is made by a medical professional has been stressed.^{19 25}

One shortcoming of using data bases such as ours, is that certain variables are missing. It was not possible for us to relate injuries to a quantitative measure of exposure such as number of games, practice, and so on. Therefore, players were analysed as a group with equal participation. There was not likely to be any differences in this respect between the athletes with concussion compared with those with ankle distortion.

Another circumstance which we assumed to be similar in both groups was that neither the anterograde nor the retrograde observational time could be controlled for the fact that it is unknown if included individuals had either immigrated to or emigrated from the region, or continued practicing sports during the complete follow-up time. With a mean age of 20–21 years, both immigration and emigration is likely, especially as Umeå is a university city. However, there is no reason to believe that this pattern differs between athletes with concussions and ankle injuries.

Summary

In summary, players who sustained a concussion were more likely to suffer injuries when compared with players with ankle sprain. It seems as if these athletes

were more injury prone, in general, as the concussion did not increase the risk for new injuries in those players. The increased injury risk was not linked to type of sport or sex.

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