

Analysis on sports and recreation activity-related eye injuries presenting to the Emergency Department

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Abstract

• **AIM:** To investigate the incidence and general characteristics of sports-related eye injuries in patients visiting the Emergency Department.

• **METHODS:** A cross-sectional, multi-center, observational study. Patients with an injured eye who visited the Emergency Department at one of nine hospitals in Korea were enrolled. All data were prospectively collected between March and September 2010 using a questionnaire. Eye injuries that occurred during risky sports were examined by gender and age. Additionally, the rate of open globe injuries that occurred with and without protective eyewear was examined for each activity. Continuous variables were compared using Student's *t*-test and categorical variables were compared using Chi-square test.

• **RESULTS:** A total of 446 patients had sports-related eye injuries. Teenagers (10–19 years old) and young adults (20–29 years old) had the most eye injuries. Eye injuries accounted for 0.2% of Emergency Department patients. Baseball was the most common cause of sports-related eye injuries, followed by soccer and hiking. Protective gear was worn by 9.4% of all patients. Patients that were 30–39 years of age had the highest rate of protective gear use, followed by patients that were 40–49 years of age. The proportion of sports-related eye injuries that were open-globe injuries was highest for soccer and hiking.

• **CONCLUSION:** Although injuries were most common in patients below the age of 10 years, these patients had the lowest rate of protective eyewear use. Injuries in adults over 40 years of age most commonly occurred during hiking, but the rate of protective eyewear use was low. Young athletes should be educated on and provided with protective eyewear and policies protective gear use should be established. For older adults, eye protection should be encouraged, especially during hiking.

• **KEYWORDS:** athletic injuries; eye injuries; protective devices; sports.

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INTRODUCTION

The number of people participating in recreational and sports activities has been increasing over recent years because of better availability, an increase in the amount of free time, and improved socioeconomic status [1]. Various injuries have been associated with such activities and eye injuries have become a concern around the world, particularly because ocular injuries can be fatal, have a high morbidity, and are often expensive to treat [2]. A nationwide study in the United States reported that only 0.4% of all sports injuries involve the eyes [3] and it is widely known that

up to 90% of all sports-related eye injuries can be prevented by using protective equipment [3-8]. Still, 40 000 to 100 000 sports-related eye injuries occurred in the United States and as many as 600 000 sports-related eye injuries occurred around the world [4-6,8]. Numerous publications have reported different eye injury characteristics and which risky activities are most associated with sports-related eye injuries. These studies used data obtained from various data collection agencies, including the National Electronic Injury Surveillance System (NEISS), the National Eye Trauma System (NETS), the United States Eye Injury Registry (USEIR), and the Canadian Ophthalmological Society (COS) [5,7,9-10]. Unlike north America, Korea does not have a specialized agency that is involved in monitoring ocular injuries. Because the prevalence of specific sports activities vary by country, the types of eye injuries observed will reflect these regional differences. Therefore, it is important to determine risk factors and characteristics for each nation or geographic region. The purpose of this study was to investigate the incidence of sports-related eye injuries in patients visiting the Emergency Department (ED). We specifically examined injury characteristics and which activities were most associated with eye injury.

SUBJECTS AND METHODS

This study was a cross-sectional, multi-center, observational study. To understand general patient characteristics, regional areas were classified as either metropolitan or provincial. Korea had been divided into 9 provinces, 6 metropolitan cities, and 1 special city at the time of this study. Eight regional emergency medical centers were selected from 5 metropolitan cities, 2 provinces, and 1 special city. An additional local emergency medical center located in Seoul was included to reflect the large population of that city. Regional emergency medical centers are government-designated hospitals where EDs have government-mandated personnel and resources. In Korea, many patients visit hospitals located in a metropolitan area and hospitals with regional emergency centers are considered to be the main hospital in that region. Patients with an eye injury that visit a hospital ED were enrolled in this study. Data were prospectively collected using a prepared questionnaire.

Eye injury patients that visited the ED at the selected hospitals between March and September 2010 were enrolled. Patients with a confirmed diagnosis following ophthalmology consultation were included in analyses. Eye injury types included eyeball injury, eye adnexa (*e.g.* lacrimal duct and lacrimal gland) injury, eyelid laceration, orbital wall fracture, and intraocular foreign body. Severe ocular trauma was defined as trauma associated with at least one of the following three occurrences: hospital admission, surgery, and complications.

The specific sports included in analyses were initially based on discussions between emergency physicians, ophthalmologists, and epidemiologists. The USEIR is a widely used format to standardize eye injury studies and was used here as a reference to create our study eye injury questionnaire. Once created, the questionnaire was localized to be more applicable to the Korean context. Data collection included patient gender and age for demographic analyses and sports activity and protective eyewear use for risk analyses. Injury type, diagnosis, and severity were also examined to better understand clinical characteristics of injuries. Eye injuries were classified with the widely used Birmingham Eye Trauma Terminology System (BETTS)^[11]. Patients were divided into age and gender groups to examine the influence of sports activity and protective eyewear use. Patients were categorized into one of the following age groups: <10 years old (children), 10-19 years old (teenagers), 20-29 years old (young adults), 30-39 years old (adults), 40-49 years old (older adults), and ≥ 50 years old (elderly).

A descriptive analysis was conducted to investigate eye injury risk by age, gender, eye injury type, sports activity type, and protective eyewear use. Continuous variables were compared using Student's *t*-test and categorical variables were compared using Chi-square test for comparisons between gender groups. Fisher's exact test was used if there were fewer than 10 data points. All statistical analyses were performed using SPSS for Windows (Version 18.0, SPSS Inc., Chicago, IL, USA) and statistical significance was defined as $P < 0.05$.

This study was approved by the Institutional Review Board of Kyungpook National University Hospital (IRB number: 2014-06-014). This study was based on data from a registry that collects information from inpatient medical records. At the time of the study, clinical care had been completed. Therefore, this study was considered low risk for infringement of patient rights and personal information and was granted exempt status (requirement of informed consent waived) by the Institutional Review Board of Kyungpook National University Hospital.

RESULTS

A total of 446 patients with sports-related eye injuries presented to the nine included EDs between March and September 2010. The majority of patients were male (88.3%) and fell into the teenager (10-19 years old, 29.8%) and young adult (20-29 years old, 24.2%) age groups. Mean patient age was 28.5 ± 15.5 y. Most patients went directly to the ED (87.9%) rather than transferring hospitals (12.1%). Protective gear was worn by 9.4% of eye injury patients and female patients (13.5%) were more likely to wear protective eyewear than male patients (8.9%). Alcohol was involved in 4.5% of sports-related injuries. The proportion of open-globe injuries was lower in male (3.6%) than in female (5.8%) patients, but

Table 1 General characteristics of the study population *n* (%)

Parameters	Male (<i>n</i> =394)	Female (<i>n</i> =52)	Total (<i>n</i> =446)	^a <i>P</i>
Patient age (a)				<0.001
0-9	32 (8.1)	4 (7.7)	36 (8.1)	
10-19	128 (32.5)	5 (9.6)	133 (29.8)	
20-29	97 (24.6)	11 (21.2)	108 (24.2)	
30-39	58 (14.7)	8 (15.4)	66 (14.8)	
40-49	48 (12.2)	5 (9.6)	53 (11.9)	
≥50	31 (7.9)	19 (36.5)	50 (11.2)	
Eye involved				0.434
Right	195 (49.5)	29 (55.8)	224 (50.2)	
Left	191 (48.5)	21 (40.4)	212 (47.5)	
Both	8 (2.0)	2 (3.8)	10 (2.2)	
Route to hospital ED				0.136
Direct	343 (87.1)	49 (94.2)	392 (87.9)	
Transferred	51 (12.9)	3 (5.8)	54 (12.1)	
Protective eyewear used				0.310 ^a
Yes	35 (8.9)	7 (13.5)	42 (9.4)	
Alcohol-related injury				0.273 ^a
Yes	16 (4.1)	4 (7.7)	20 (4.5)	
Open-globe injury				0.434 ^a
Yes	14 (3.6)	3 (5.8)	17 (3.8)	
Severity of injury				0.973
Severe	75 (19.0)	10 (19.2)	85 (19.1)	

^aFisher's exact test.

Table 2 Incidence of in patients visiting the ED

Hospital	Total No. of ED visit	No. of eye injury patients	Sports-related eye injuries		
			<i>n</i>	Proportion of ED visits (%)	Proportion of eye injuries (%)
A	50048	1144	69	0.1	6.0
B	21426	563	36	0.2	6.4
C	23297	345	43	0.2	12.5
D	18588	212	16	0.1	7.5
E	32254	324	29	0.1	9.0
F	21991	522	44	0.2	8.4
G	21119	1111	92	0.4	8.3
H	20627	394	38	0.2	9.6
I	21411	741	79	0.4	10.7
Total	230761	5356	446	0.2	8.3

this difference was not statistically significant. The rate of severe injury was slightly higher in female (19.2%) than in male (19.0%) patients, but this difference was not statistically significant. The general characteristics of patients with sports-related eye injuries are summarized in Table 1.

A total of 5356 eye injury patients visited the selected nine

EDs between March and September 2010. As already stated, 446 of these patients had sports-related eye injuries, accounting for 0.2% of ED patients and 8.3% of eye injury patients. The proportion of eye injuries that were sports-related varied between 6.0% and 12.5% in the nine hospitals examined (Table 2).

Table 3 Causative sport activity of eye injury examined by gender and age n (%)

Causative activities	Gender		Age groups						Total
	M (n=394)	F (n=52)	0-9 (n=36)	10-19 (n=133)	20-29 (n=108)	30-39 (n=66)	40-49 (n=53)	≥50 (n=50)	
Baseball	132 (97.1)	4 (2.9)	8 (5.9)	50 (36.8)	46 (33.8)	22 (16.2)	10 (7.4)	0 (0)	136
Soccer	113 (96.6)	4 (3.4)	10 (8.5)	51 (43.6)	23 (19.7)	20 (17.1)	8 (6.8)	5 (4.3)	117
Hiking	38 (77.6)	11 (22.4)	2 (4.1)	0 (0)	5 (10.2)	5 (10.2)	10 (20.4)	27 (55.1)	49
Badminton	31 (75.6)	10 (24.4)	2 (4.9)	6 (14.6)	6 (14.6)	8 (19.5)	13 (31.7)	6 (14.6)	41
Basketball	17 (100.0)	0 (0)	1 (5.9)	4 (23.5)	11 (64.7)	0 (0)	0 (0)	1 (5.9)	17
Tennis	13 (86.7)	2 (13.3)	3 (20.0)	2 (13.3)	2 (13.3)	3 (20.0)	3 (20.0)	2 (13.3)	15
Golf	5 (83.3)	1 (16.7)	0 (0)	0 (0)	0 (0)	2 (33.3)	2 (33.3)	2 (33.3)	6
Others	45 (69.2)	20 (30.8)	10 (15.4)	20 (30.8)	15 (23.1)	6 (9.2)	7 (10.8)	7 (10.8)	65

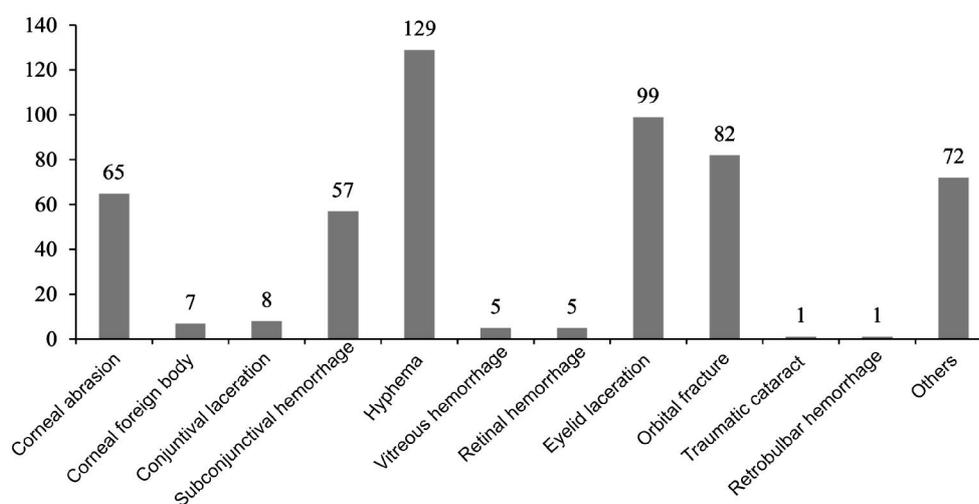


Figure 1 Distribution of eye injury diagnoses.

The causes of sports injuries in age and gender groups are summarized in Table 3. Teenagers were the most commonly injured age group (29.8%), followed by young adults (24.2%) and children (8.1%). Baseball was the most common cause of sports-related eye injury, followed by soccer, hiking, badminton, basketball, tennis, and golf. Baseball and soccer injuries occurred most often in teenagers (36.8% and 43.6% respectively), followed by young adults (33.8% and 19.7% respectively) and adults (16.2% and 17.1% respectively). Hiking injuries occurred most often in older adults (20.4%) and elderly patients (55.1%) and badminton injuries occurred most often in older adults (31.7%). Basketball injuries occurred at similar rates as in the general population and most often affected teenagers (23.5%) and young adults (64.7%). Tennis and golf injuries occurred at similar rates in all age groups examined. The proportion of females participating in badminton (24.4%) and hiking (22.4%) was higher than in any other sports activity examined.

The most common diagnoses were hyphema [129 cases (24.3%)], orbital wall fracture [82 cases (15.4%)], corneal abrasion [65 cases (12.2%)], and subconjunctival hemorrhage [57 cases (10.7%)] (Figure 1).

Figure 2 compares the number of severe injuries that occurred during participation in each sport. Soccer accounted for the highest number of severe sports-related injuries [27 cases (23.1%)]. Additionally, 83.3% of injuries that occurred during golf and 26.8% of injuries that occurred during badminton were severe. Adults had the highest rate (21.2%) of protective eyewear use, followed by older adults (13.2%). Not surprisingly, the most injured age groups had the lowest rate of protective eyewear use (teenagers: 9.8%; young adults: 4.6%). Badminton players were most likely to have been wearing protective eyewear (19.5%). No basketball, golf, or tennis participant wore protective eyewear and a mere 4.1% of hikers wore any gear. Of the eye injuries that occurred during hiking and soccer, 10.2% and 4.3% were open-globe injuries.

DISCUSSION

The incidence of sports-related eye injuries has been steadily increasing. A study conducted in the United Kingdom showed that only 0.7% of all eye injuries were sports-related in the early 20th century. However, this figure has risen to over 25% in the past 60y [12]. The current study showed that 8.3% of all eye injuries were sports-related. This is in

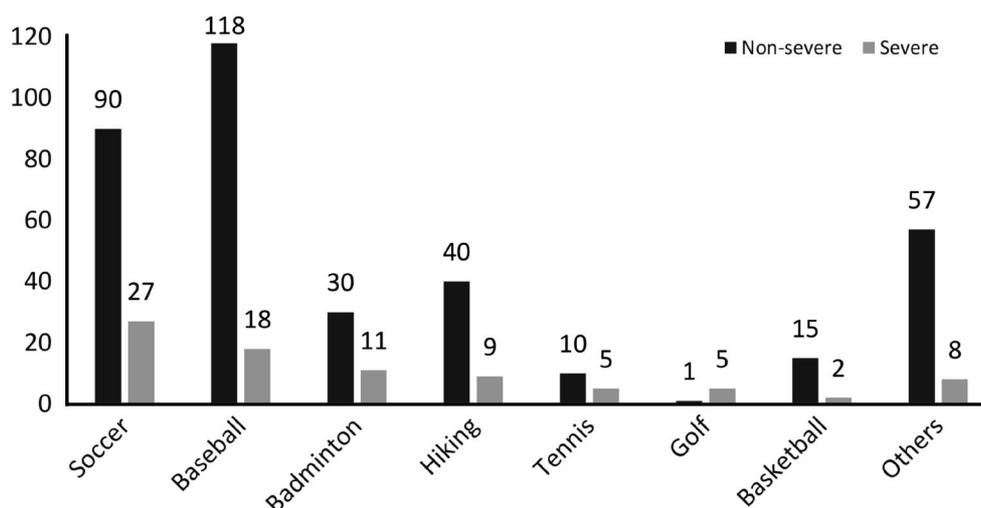


Figure 2 Number of severe eye injuries during each sport.

agreement with other studies conducted in Korea (7.6% four years ago) and around the world (2% to 12.9%) since 2000^[13-14]. On a different note, eye injuries have a high incidence among all sports-related injuries. One study in the United States showed that 42% of people that participate in sports activities suffer eye injuries^[10]. In United States, up to one-third of all cases of blindness are attributable to sports^[15]. Lundin *et al*^[16] also reported that approximately 28% of trauma-associated enucleations resulted from an injury sustained during recreational activities or sports.

Studies on the epidemiology and risk factors of eye injuries should be performed as the next step towards preventing such injuries. Even with the use of established systematic data collection systems (*e.g.* NEISS and USEIR), Napier *et al*^[5] suggest the use of a standardized data collection method that includes details such as demographics, initial diagnosis, and final outcome. Researchers outside of the United States have also proposed establishing a similar local registry^[8]. Korea lacks such systems and activities and has very low public interest. Therefore, this study was organized and performed to collect nationwide data and further the objectives stated above.

Like previous studies^[1,3,10,12,17], we observed a male dominance in sports-related eye injuries. Our findings on the age distribution of eye injuries was also similar to previous studies, which either showed that eye injuries were most prominent in adolescents and young adults or that the mean age of patients with eye injuries was in the early 20s^[1-2,10,14]. Around the world, geographical and cultural distinctions influenced which sports were most commonly associated with eye injuries. Studies conducted in the United Kingdom reported soccer as the most common cause of eye injury^[12,18], while those conducted in the United States reported baseball and basketball as the most common cause of eye injury^[3-5,7]. Eye injuries most commonly occurred during floorball in northern and central Europe and during racquet sports (*e.g.*

squash) in Australia^[14,19-21]. In the present study, baseball and soccer participation were the most common causes of eye injuries, but, interestingly, hiking was also identified as a major cause of eye injury in adults older than 50y. A recent survey examining hobbies in the Korean population showed that hiking is the most favored^[22], presumably to maintain a healthy lifestyle. Additionally, most hikers do not wear protective eyewear while hiking.

We found that hyphema was one of the most common sports-related eye injuries, which was similar to findings of a study in the United States^[5]. Other common injuries in our study population included eyelid laceration, orbital wall fracture, and corneal abrasion. A similar study by Choi and Shin^[1] also reported lid contusion, conjunctival hemorrhage, and hyphema, in that order, as frequent injury types. The mechanisms of injury have been classified by Ong *et al*^[17] as ball-to-eye, body part-to-eye, and bat/racquet-to-eye. They found that 81.2% of injuries occurred from ball-to-eye contact. Our study found that basketball and soccer injuries generally occurred from either body part-to-eye or ball-to-eye contact. Therefore, basketball and soccer injuries mainly occurred from blunt trauma, which led to hyphemas and orbital wall fractures. In contrast, hiking injuries generally led to scratches from contact with small objects, the majority of which could have been prevented by wearing simple protective gear. Jones^[23] and Capao Filipe *et al*^[9] also agreed that sports-related eye injuries are mainly caused by balls or small objects. Some other researchers have also concluded that direct force accounts for a small proportion of injuries^[1,18]. Leivo *et al*^[14] claim that 80% of sports-related eye injuries involve instrument-to-eye contact, but Jones^[23] only reported a rate of 12%. Pieper^[7] noted that baseball and basketball players were most often injured by contact with the ball and the opponents' body, respectively.

The cost of treating eye injuries is considerable^[3] and the total cost, including direct and indirect costs, is not yet known^[2].

Many studies on eye injuries highlight the importance of wearing protective eyewear. However, such equipment is not widely used on the sports field^[17,24]. For example, Eime *et al*^[19] reported that less than 10% of Australian players equip themselves properly. Several studies have reported that very few or none of the patients sustaining an eye injury wore eye protection^[3,14,17]. Our study showed that less than 10% of injured patients protected their eyes. For young players, especially those under 30 years of age, our results suggest that a great part of sports-related eye injuries stems from the low rate of protective eyewear use. Interestingly, in patients over 50 years of age, most injuries occurred during activities (*e.g.* hiking) that participants do not generally wear eyewear. Considering our results, we suggest that more people engaging in soccer and hiking should wear protective eyewear. The risk of eye injury in unprotected players may be categorized^[8,25]. We found that baseball and basketball are high risk activities and that soccer, badminton, tennis, and golf are moderate risk activities. In our opinion, a simple goggle may be sufficient for hikers because injuries are not likely to be high-speed, with most caused by untrimmed branches. However, guideline-compliant eye protection should be mandatory for ball sports, where most injuries occur from high-speed, high-energy collisions. Furthermore, we suggest that public campaigns should be launched to educate players and promote and provide adequate eyewear. Some researchers advocate such legal obligations^[24]. A study in Canada showed that after wearing protective eye gear was made mandatory, the incidence of eye injuries was significantly reduced^[26]. Additionally, it is mandatory in Finland that floorball players wear adequate eye protection while playing^[14]. Napier *et al*^[5] suggested taking a legislative approach even though there may be cases of noncompliance during unsupervised play. They felt this was particularly important because athletes prefer not to wear protective gear, but the majority of injured players are young adults and children that require supervision. However, athletes have mixed opinions on what they would prefer. Danis *et al*^[27] explained that many players are willing to wear facial shields for protection if the proper gear is easily available.

This study revealed that more open-globe injuries occurred in people who participated in hiking and soccer. It is noticeable that our rate is considerably higher than that found in another study^[14] and that soccer is not a sport commonly associated with open-globe injuries^[28]. In this study, all open-globe soccer injuries occurred in players using protective eyewear. Therefore, it may be that inappropriate equipment increases secondary injuries, including penetrating injuries, because of broken eyewear^[4]. Many studies and guidelines recommend that protection devices should follow the American Standard of Testing Materials (ASTM) standards^[4-5,7-9,10,24-25,28]. Soft contact lenses offer almost no protection from injury and

hard lenses, when worn without proper eyewear, actually increase the likelihood of corneal abrasion in an eye injury^[5,8,23,29]. It is well-known that the likelihood of eye injury is increased when protective gear is not worn. Similar to our results, one study claimed that the likelihood of eye injury is actually higher when non-ASTM compliant gear is worn than when no gear is worn^[6].

This study has some limitations. First, while some patients with eye injuries visited the ED, others chose to visit the ophthalmology outpatient clinic. These patients were not included in this study. Therefore, our results may not accurately represent epidemiologic characteristics of sports-related eye injuries in the entire Korean population. Second, many studies have shown that paintball and combative sports, including martial arts, put participants at high-risk for sports-related injuries, many of which can be very serious^[1,5-10,13,29]. However, data regarding these activities were not collected in this study. Third, except for open-globe injuries, our study did not examine the severity of visual acuity loss or follow-up status. Fourth, our study only examined injuries that occurred between March and September. Therefore, we were not able to consider seasonal fluctuations in ocular injuries.

This is the first multicenter study conducted in Korea to examine sports-related eye injuries. With this study, we discovered that injuries tend to occur more commonly in baseball, soccer, and hiking. In addition, injuries occurred most often in patients between 10 and 29 years of age and fewer than 1 in 10 patients with sports-related eye injuries wore protective gear. While injuries in adults over 40 years of age mostly occurred during hiking, the use of eye protection was low. Therefore, for sports associated with eye injuries, it is appropriate to not only promote the use of eye protection for participants in soccer, baseball, and hiking, but to distribute protective gear. Administrative strategies that educate players and promote wearing proper gear during high risk sports activities should be established for young athletes. For older adult groups, the use of eye protection in Korea should be emphasized, especially during hiking.

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