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Prevention of Sports-Related Eye Injuries and the Long-Term Quality of Life and Performance of Athletes: A Narrative Review

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Abstract

Introduction: Optimal functioning of the visual system is key in competitive sport; however, eye injuries are the second most common cause of injury among athletes, constituting a risk of permanent impairment of performance and quality of life (QoL). The aim of this narrative review is to systematise knowledge on the aetiology of eye injuries in sport, available prevention strategies, and barriers to the utilisation of personal protective equipment.

Materials and Methods: A comprehensive literature search across PubMed, Web of Science, Scopus, and Google Scholar was conducted to identify relevant publications. The gathered evidence was evaluated using a narrative synthesis approach, focusing primarily on original studies that provided epidemiological data and insights into athletes' use of protective equipment.

Results: The highest risk rates are recorded in racket sports, team sports and combat sports. Although certified polycarbonate protective equipment is estimated to prevent approximately

90% of injuries, the sporting environment is characterised by the so-called ‘athlete’s paradox’ – an extremely low rate of *compliance* with protective recommendations. This phenomenon is credited to ergonomic barriers (fogging, subjective restriction of the field of view) and socio-cultural barriers (fear of stigmatisation). The current literature also reveals methodological gaps, including, above all, a shortage of longitudinal studies that track long-term complications and quality-of-vision (QoV) parameters in former athletes.

Conclusions: Ophthalmic injuries entail significant physical, psychosocial and economic burdens. Overcoming behavioural barriers demands implementing top-down, systemic regulations mandating the use of protective eyewear (particularly in junior leagues), standardising medical records, and closely collaborating with materials engineering to optimise the user experience (UX) of protective equipment.

Keywords: eye injuries; sport; sports medicine; quality of life; eye protection; injury prevention; compliance.

1. Introduction

1.1. The role of the eye in sport

Optimal functioning of the visual system plays a key role in determining sporting success. It is estimated that 80% of the sensory information athletes process during competitive play is visual (Moe et al., 2023). This visual guidance is vital for coordinating eye-hand movements, which is key to the successful performance of complex motor tasks (Moe et al., 2023). Binocular depth perception (stereopsis) is also of significant importance in many sporting disciplines. Central neural processing enables the integration of this visual information into decision-making processes and its precise coordination with limb and whole-body motor control during sporting activity (Moe et al., 2023). Consequently, sports medicine and ophthalmology remain closely interlinked, a relationship of utmost importance for sustaining high performance in athletes (Moe et al., 2023).

1.2. Definition and significance of the problem

Ocular injuries are the second most common type of injury in sport, second only to musculoskeletal injuries (Lauga et al., 2024). The nature of physical contact and the dynamics of sporting activity mean that athletes have a significantly higher risk of eye injuries relative to the general population (Moe et al., 2023). Globally, it has been estimated that approximately 600 000 sports-related eye injuries occur each year, of which as many as 13 500 result in irreversible vision loss (Zhang et al., 2023). Data from the United States is particularly telling, where as many as one-third of all cases of blindness are directly attributable to sports-related incidents (Moon et al., 2016). Such injuries are characterised by

a high incidence and incur significant treatment and healthcare costs (Moon et al., 2016). It must be strongly emphasised that even incidents that initially appear minor can have extremely serious consequences, which can permanently and adversely affect the athlete's health, physical performance and future professional career (Lauga et al., 2024). Damage to the eyes can lead to lifelong consequences; therefore, any post-traumatic deterioration in vision always requires rigorous monitoring and specialist management (Moe et al., 2023).

1.3. Aim of the study

The aim of this study is to identify the aetiology of eye injuries, which is a prerequisite for designing targeted, discipline-specific prevention programmes (Hoskin et al., 2019). However, the literature indicates a widespread problem of low acceptance of recommended protective equipment amongst athletes (Hoskin et al., 2016). The main psychosocial and ergonomic barriers to implementing protective measures include concerns about appearance, a subjective sense of restricted field of vision, fogging of optical components, and general physical discomfort (Hoskin et al., 2016). Understanding the nature of these design and aesthetic constraints is necessary for optimising the design of a new generation of individual protective equipment (Aiello et al., 2026). Taking the above aspects into account, the aim of this article (a narrative review) is to summarise the most common risks and mechanisms of eye injuries, analyse available prevention methods, and identify the barriers preventing athletes from using protective equipment.

2. Literature identification and selection

2.1. Methodology

To construct this narrative review, a comprehensive literature search was conducted to identify relevant and up-to-date publications on sports-related eye injuries. The search included the PubMed, Web of Science, Scopus and Google Scholar databases. The retrieved literature was critically analysed and thematically synthesised to provide a broad overview of the available evidence. Searches were performed using combinations of keywords related to eye injuries, sports, eye protection, trauma mechanisms and specific sports disciplines. Additional relevant publications were identified through reference lists of selected articles.

2.2 Selection approach

Publications were selected based on their relevance to the objectives of this review, with preference given to original studies reporting epidemiological data, injury mechanisms, preventive strategies and the use of protective eyewear. Review articles were consulted for background information but were generally not included as primary sources of evidence where original studies were available.

As this study was designed as a narrative review, no formal assessment of methodological quality or risk of bias of the included studies was performed. Evidence from the selected publications was synthesised narratively, with particular emphasis on epidemiology, mechanisms of injury, preventive strategies, long-term outcomes and barriers to the use of protective eyewear.

3. Epidemiology of eye injuries in sport

3.1. High-risk sports and their specific characteristics

The risk of sustaining an eye injury during sporting activities depends directly on the nature of physical contact, the specific characteristics of the equipment used, and the size and speed of the moving object in play (Zhang et al., 2023). Racket sports are generally classified as high-risk, and epidemiological analyses show that they account for 28–52% of all exercise-related eye injuries (Mazarelo et al., 2024). In badminton, a sport characterised by a global, dynamic increase in the number of active players, the main aetiological factor is a direct impact by the shuttlecock (Hong et al., 2024). Due to the small diameter of its base, the shuttlecock bypasses the eye socket's natural bony protection, which, in the absence of adequate eye protection, leads to serious ophthalmic complications (Hong et al., 2024; Mazarelo et al., 2024). The rise in participation in other racket sports, such as padel, correlates with the increasing number of severe, closed injuries to the eyeball reported in clinical centres (Aiello et al., 2026; Thörn & Jakobsson, 2021). Padel poses a specific risk to the eye due to the dynamic nature of rallies on a closed, relatively small court, the presence of walls that cause unexpected ricochets, and the short distance between competing players (Aiello et al., 2026; Thörn & Jakobsson, 2021). In the United States, a similar sharp rise in emergency ophthalmological interventions has been observed in pickleball, where the intensity of play at the net and frequent volley shots drastically reduce a player's reaction time (Aiello et al., 2026; Boopathiraj et al., 2024).

In team and contact sports, the distribution of risk factors differs. For example, a 5-year retrospective study at an Australian referral centre revealed that the most common causes of sports-related eye injuries were, in order: football (18,2%), Australian rules football (17,1%) and basketball (12,0%) (Ashraf et al., 2022). In contrast, in Northern and Central European countries, floorball has emerged as a discipline generating a very high percentage of eye injuries (Moe et al., 2023; Moon et al., 2016). A multicentre study conducted in China showed that, among the local population, the highest number of hospitalisations for sports-related eye injuries was associated with football (46,9%), basketball (27,1%) and badminton (16,7%) (Zhang et al., 2023). Combat sports exhibit a distinct risk profile – boxing is associated with a higher rate of general eye injuries compared with mixed martial arts

(MMA), although MMA is reported to have a significantly higher proportion of secondary orbital fractures (Chang et al., 2024). The pattern of post-traumatic injuries among professional MMA fighters is dominated by lacerations of the eyelids and brow ridges, as well as severe fractures of the facial skeleton (Chang et al., 2024).

3.2. Demographic groups

The distribution of sports-related eye injuries is characterised by a strong and consistent correlation with the gender and age of those participating in physical activity (Boden et al., 2017; Moon et al., 2016; Zhang et al., 2023). In all the epidemiological studies analysed, a clear predominance of men was observed among ophthalmological patient cohorts, which is attributable to their greater participation in high-impact contact sports (Ohana & Alabiad, 2021; Zhang et al., 2023). In South Korea, men accounted for 88,3% of patients presenting to hospital accident and emergency departments (ED), whilst in a multicentre study in China, their proportion reached 93,9% of hospitalised patients, which translates to a sex ratio (M:F) of 15,4:1 (Moon et al., 2016; Zhang et al., 2023). Similar trends were observed in the United States, where men accounted for 78,0% of patients with traumatic anterior chamber haemorrhage (*hyphema*), and in Japan, where they accounted for 83,4% of orbital *blowout fracture cases* (Ambat et al., 2024; Iftikhar et al., 2021).

Incidence rates also differ markedly depending on the specific sport practised (Boden et al., 2017). In most popular team and contact sports, eye injuries primarily affect adolescents and young adults under 30 (Moon et al., 2016; Zhang et al., 2023). For example, in American school and university sports, the overall rates of ophthalmic incidents were 0,68 and 1,84 per 100 000 *athlete-exposures* (AE), respectively. At the secondary school level, the sports with the highest injury rates were baseball (1,68), boys' basketball (1,46), and girls' field hockey (1,38) (Boden et al., 2017). Among young tennis players, the peak injury rate in males occurs during the early school years, whilst in females, the highest incidence of injuries is observed during secondary school (Mysore et al. 2026). Pickleball exhibits a distinct age profile, with the average age of ophthalmology patients in the United States exceeding 58 years (Shah et al., 2026). Among older players, falls on the court are a significant risk modifier, accounting for over 15% of incidents and resulting in, among other things, serious fractures of the orbital structures (Shah et al., 2026). In paediatric cohorts, injuries sustained in non-sporting contexts are also considered to be of significant epidemiological importance – it is estimated that between 44% and 76% of paediatric ophthalmic incidents occur in the home environment (Hoskin et al., 2016).

3.3. The specific nature of injuries among amateur and professional athletes

An analysis of the structural differences between organised professional and amateur sport shows that elite leagues have highly developed medical and organisational supervision, whilst recreational activity is characterised by a significantly lower level of compliance with safety rules (Radtke et al., 2021). Nevertheless, in sports such as badminton, the absence of mandatory eye protection regulations poses a high risk of serious ocular trauma, regardless of the level of competition (Mat Nawi & Bastion, 2026). In cohorts of elite athletes competing at the highest international level, severe eye injuries are reported only rarely, a direct result of the implementation of institutionalised prevention programmes and ongoing ophthalmological care (Moe et al., 2023).

However, professional contact sports with a commercial focus are characterised by different features. For example, among professional mixed martial arts (MMA) fighters, eye conditions occur frequently, accounting for over 25% of all diagnosed injuries (Chang et al., 2024). These injuries are predominantly lacerations of the eyelids and brow ridges, as well as fractures of the orbital bones, which substantially affect the course of competition and necessitate absences lasting several weeks due to mandatory medical suspension and a ban on contact training (known as '*no-contact time*') (Flitsos et al., 2021). In contrast, injuries sustained in amateur and recreational sports—as seen, for example, in rapidly growing disciplines such as padel—typically affect middle-aged individuals (average age approximately 41 years) (Aiello et al., 2026). In this group, the predominant clinical problem is corneal abrasions caused by direct blunt impact, which is exacerbated by an extremely low level of acceptance and use of recommended eye protection measures (Aiello et al., 2026).

4. Mechanisms and typology of injuries

4.1. Biomechanics of blunt trauma

The vast majority of sports-related eye injuries are closed injuries, most commonly caused by a direct impact from a blunt object (Ohana & Alabiad, 2021). The extent and clinical presentation of these injuries are determined primarily by the mass, velocity, contact area and deformability (elasticity) of the impacting object (Rohowetz et al., 2025). Large, highly deformable balls (e.g., those used in football) absorb some of the energy by bearing against the bony rim of the orbit; nevertheless, because of the prolonged contact, they generate pressure waves. The accompanying violent anteroposterior deformation of the eyeball, combined with the vacuum effect (during the return to its original shape), induces destructive compressive and tensile forces, which are transmitted directly to the retinal structures (Zhang et al., 2023). Conversely, objects of smaller diameter and high stiffness (e.g., baseballs or golf balls), travelling at higher speeds, easily bypass the protective rim of

the orbit. They transfer kinetic energy over a small surface area and in an extremely short time, which significantly increases the risk of complete *globe rupture* (Zhang et al., 2023; Hong et al., 2024). The pathomechanism underlying fractures of bony structures following blunt trauma is explained by two fundamental concepts (Ohana & Alabiad, 2021). The hydraulic theory posits that sudden retraction (posterior displacement) of the eyeball induces a critical increase in intraorbital pressure, leading to rupture of the thinnest intraorbital bony walls (Ohana & Alabiad, 2021). The buckling theory, on the other hand, proposes that the impact energy applied directly to the massive rim of the orbit causes a momentary, elastic deformation of the bone, which, by transmitting stress waves deep into the orbit, leads to the collapse of its most delicate structures (Ohana & Alabiad, 2021).

4.2. Damage to the anterior and posterior segments of the eye

One of the most common consequences of a blow to the eye, particularly in racket sports, is hyphema. This condition results from shear forces that cause rupture of the blood vessels supplying the iris and ciliary body (Wang et al., 2020). Injuries to the posterior segment of the eye pose an equally significant clinical risk. During such injuries, sudden anteroposterior compression and secondary equatorial enlargement of the eyeball generate tensile forces, in which the traction exerted by the adjacent vitreous body on the retina plays a key role (Rohowetz et al., 2025). This phenomenon predisposes the eye to severe complications, such as retinal tears, detachment, or dialysis (detachment from the ciliary margin), which are among the most common post-traumatic pathologies observed in basketball and football (Zhang et al., 2023). Conversely, in the case of penetration by a small ball travelling at high speed, the shock wave transmitted deep into the eye causes instantaneous compression of the optic disc, displacing it backwards by approximately 2,6 mm (Hong et al., 2024). This type of impact carries a high risk of post-traumatic neuropathy, ganglion cell necrosis and permanent vision loss. In contact sports, superficial corneal erosions are also commonly diagnosed, usually resulting from accidental contact with an opponent's hand during direct competition (Ohana & Alabiad, 2021). In the context of *outdoor* activities, such as hiking, similar micro-injuries to the ocular surface epithelium most commonly result from contact with small elements of the natural environment (Moon et al., 2016).

4.3. Open and penetrating injuries

A different and less common group of eye trauma consists of open-globe injuries, such as penetrating and perforating wounds, defined as a full-thickness tear of the eye wall. Despite their lower incidence in a sporting context, these conditions are associated with an extremely poor prognosis for preserving useful visual acuity (Ohana & Alabiad, 2021).

Their aetiology usually involves the impact of sharp objects or small-diameter projectiles travelling at high speed (e.g. paintball pellets or badminton shuttlecocks) (Ohana & Alabiad, 2021). It must be strongly emphasised that, in many cases, penetration of the eyeball is secondary in nature. This phenomenon most commonly occurs when uncertified prescription glasses, unsuitable for the specific sport, shatter upon direct impact with a ball or upon collision with another player (Ohana & Alabiad, 2021).

4.4. Radiation and environmental injuries

Regardless of the presence of mechanical trauma, athletes’ eyes are constantly vulnerable to the harmful effects of environmental factors, particularly prolonged exposure to ultraviolet (UV) radiation. The increased risk of phototoxic damage mainly affects individuals who practise water sports (including sailing and surfing) and numerous winter sports (Moe et al., 2023). The elevated risk in these disciplines is attributed to the high albedo of sunlight reflected from water and snow surfaces (Moe et al., 2023). This phenomenon significantly increases the total radiation dose reaching the anterior segment of the athlete’s eye, predisposing them, among other things, to acute inflammation of the cornea and conjunctiva (Moe et al., 2023).

4.5. Summary of mechanisms and potential complications of the most common eye injuries

In order to systematically summarise data on the typology of sports-related eye injuries, the following summary presents the correlations between a specific type of injury, its biomechanical aetiology, potential complications and the sports disciplines characterised by the highest risk rate (Table 1).

Table 1. Characteristics, biomechanical aetiology and possible clinical consequences of the most common sports-related eye injuries.

Type of injury (Diagnosis)	Main biomechanical mechanism	Examples of sports	Potential long- term effects (QoL / QoV):
Anterior chamber haemorrhage (Hyphema)	Blunt trauma; sudden compression causing rupture of the blood vessels in the iris (shear forces). (Wang et al.,	Badminton (Zhang et al., 2023), football (Zhang et al., 2023), basketball (Zhang et al., 2023), squash	Secondary (post- traumatic) glaucoma, chronic ocular hypertension.

	2020).	(Ashraf et al., 2022).	
Retinal detachments and tears	Sudden compression and equatorial enlargement of the eyeball, traction by the vitreous body (Rohowetz et al., 2025).	Basketball (Zhang et al., 2023), football (Zhang et al., 2023), tennis (Rohowetz et al., 2025), padel.	Permanent reduction in visual acuity, photopsia, blindness.
Fractures of the orbital walls (blowout fracture)	Impact by an object wider than the orbit (hydraulic theory/bone buckling theory) (Ohana & Alabiad, 2021).	Baseball/softball (Ambat et al., 2024), rugby/American football (Ambat et al., 2024), martial arts (MMA, boxing) (Ambat et al., 2024).	Permanent diplopia and enophthalmos.
Corneal erosions	Tangential, superficial contact with a foreign body or an opponent's finger (Ohana & Alabiad, 2021; Moon et al., 2016).	Basketball (Ohana & Alabiad, 2021); hiking (Moon et al., 2016).	Recurrent corneal erosion, chronic pain, photophobia, corneal ulceration.
Open/penetrating eye injury	Impact by a micro-pellet with immense energy or secondary penetration by shards of broken spectacles (Zhang et al., 2023; Ohana & Alabiad, 2021)	Paintball, golf, badminton (secondary injury caused by the lenses) (Ohana & Alabiad, 2021); martial arts (Ashraf et al., 2022).	Irreversible loss of vision may necessitate removal of the eyeball (enucleation).

5. Long-term consequences for quality of life and performance

5.1. Direct effects (Sporting career)

When considering the issue of sports-related eye injuries, the damaging impact on an athlete's current career must first and foremost be taken into account. In the short term,

such incidents result in a forced, and often prolonged, absence from training and competitive tournaments. An illustrative clinical case described in the literature is that of the basketball player Kareem Abdul-Jabbar, who was forced to take breaks from playing due to corneal erosion and, later in his career, struggled with recurrent corneal erosion syndrome (Hou et al., 2022). More serious conditions, such as complex, closed-head injuries to the eyeball caused by being struck by a football, may rule a professional player out of full contact training for a period of up to 8 weeks (Lauga et al., 2024). It should be emphasised that any acquired visual function disorders – including diplopia (double vision), reduced visual acuity or photophobia (sensitivity to light) – directly impair current sporting performance (Moe et al., 2023). Furthermore, the high psychophysical strain inextricably linked to elite competition may predispose athletes to subclinical eye conditions, such as chronic central serous chorioretinopathy (CSCR). In the absence of adequate diagnosis, this condition significantly impairs an athlete's perceptual and decision-making abilities (Moe et al., 2023). Furthermore, even when complex injuries in professional athletes are successfully treated, a return to full fitness rarely equates to the restoration of perfect visual acuity, although appropriate optical correction usually allows them to maintain their independence in daily life, including the ability to drive motor vehicles (Lauga et al., 2024).

5.2. Long-term effects (Daily life and quality-of-life indicators)

The consequences of sports-related eye injuries may manifest themselves after a considerable delay, leading, in extreme cases, to lifelong complications (sequelae) (Moe et al., 2023). Long-term clinical complications include, amongst others, post-traumatic cataract and secondary glaucoma, which develops against a background of damage (recession) to the drainage angle (Ohana & Alabiad, 2021). Severe injuries to the posterior segment of the eye, caused by impact from fast-moving objects (e.g. sports balls or paintball pellets), remain particularly dangerous, as they very often result in irreversible impairment of best-corrected visual acuity (Rohowetz et al., 2025). The long-term effects of such incidents are assessed using validated indicators of quality of life (QoL) and quality of vision (QoV). Survey studies among the padel-playing population have shown that, within the group of individuals who had sustained an injury (accounting for 10,3% of all respondents), as many as 25% experienced a long-term – lasting more than a month – reduction in QoL, a decline in QoV was recorded in 15%, and 8,3% of patients reported a secondary decline in work performance (Aiello et al., 2026).

The long-term effects of trauma in paediatric cohorts represent a particularly critical social problem, as complications have an impact on patients' entire future personal and professional lives. The long-term ophthalmological prognosis for children is significantly

worse than for adults, due to the immaturity of the visual system and the high risk of developing amblyopia. It is estimated that 12- 14% of minors following a severe injury experience blindness or profound visual impairment (Hoskin et al., 2016). Long-term retrospective Australian analyses establish that sports-related injuries in children pose a premature and long-term threat to vision-related quality of life (Ashraf et al., 2022). The situation becomes particularly dire for patients with monocular vision loss – any injury to the second (healthy) eye would have catastrophic consequences for their ability to live independently, making the use of protective eyewear absolutely essential during all activities (Yahalomi et al., 2025).

5.3. Psychosocial effects and economic burden

The complex neuroanatomy and sensitivity of the eye mean that the consequences of injury to this organ extend far beyond an isolated physiological deficit. Such injuries predispose athletes to long- term psychosocial disorders and are a significant cause of reduced general well-being in this population (Ashraf et al., 2022). When reflecting on the long-term effects of maxillofacial and orbital injuries – characteristic, amongst other things, of contact sports – related phenomena, including neurological micro-injuries, must be taken into account. Studies involving mixed martial arts (MMA) competitors show that a history of head trauma may make individuals prone to difficulties in speech processing, impaired verbal memory and a decline in overall psychomotor speed in the future (Ferretti et al., 2024). These deficits have an extremely detrimental effect on an individual's social status long after they have ceased sporting activity (Ferretti et al., 2024). Loss or impairment of vision affects not only the individual concerned but also has a strong negative impact on the functioning of their entire family (Chang et al., 2024). Prevention of permanent visual impairment is therefore a key mechanism for protecting entire households from a drastic reduction in their standard of living (Zhang et al., 2023; Mazarelo et al., 2024).

The need to implement strict preventive measures is also supported by compelling arguments in health economics (Ashraf et al., 2022). The treatment of serious ophthalmic injuries, which are often accompanied by maxillofacial injuries, entails a major financial burden. This is perfectly illustrated by a Swiss cost analysis conducted in the emergency department in Bern, covering adult patients who sustained injuries in floorball accidents. The analysis showed that whilst conservative treatment of minor injuries cost less than 500 Swiss francs (CHF), complex conditions requiring hospitalisation and surgical interventions (including orthopaedic and maxillofacial procedures) generated costs ranging from several thousand to tens of thousands of francs per patient (Radtke et al., 2021).

6. The gold standard of prevention: Eye protection measures

6.1. The evolution of protective equipment and quality standards

The use of appropriate personal protective equipment is the foundation of preventing eye injuries in sports. Standard prescription spectacles do not provide the required protection and may even constitute an additional risk factor. The shattering of their lenses upon impact can transform a blunt injury into much more severe penetrating and perforating damage to the eyeball (Hoskin et al., 2019; Zhang et al., 2023). With advances in materials engineering, polycarbonate has become the universal and leading material for the manufacture of protective lenses (Hoskin et al., 2016). This material demonstrates approximately 20 times greater impact resistance than standard mineral glass, thereby optimising its protective effectiveness (Ohana & Alabiad, 2021). However, the certification of safety equipment is based on rigorous quality standards. Internationally, the standards of the American Society for Testing and Materials (ASTM) play a key role – including the baseline F803 standard and the F3164-19 standard, which has been updated for racket sports (Mazarelo et al., 2024). Modern assessment protocols have moved away from the simple criterion of minimum lens thickness in favour of dynamic ballistic tests, which verify the integrity of the entire frame and lenses when struck by high-kinetic-energy objects (Hoskin et al., 2016).

6.2. Protective effectiveness and evidence of injury reduction

The effectiveness of certified protective equipment in reducing injury rates is indisputable and supported by strong scientific evidence (*evidence-based medicine*). Clinical studies and the positions of leading medical societies consistently indicate that the use of appropriate protective eyewear prevents up to 90% of sports-related eye injuries (Moe et al., 2023; Mohseni et al., 2026; Shah et al., 2026; Kluś et al., 2026). The protective properties of polycarbonate are confirmed by analyses utilising advanced biomechanical simulations. These have shown that certified visors effectively absorb and redistribute the kinetic energy of impacts. This process reduces tensile stress on the retina by 47-61%, almost completely preventing the occurrence of the most serious conditions (including retinal detachment and haemorrhages) (Shah et al., 2026).

The most reliable population-level data are derived from analyses of top-down interventions, in which sports federations have mandated the use of protective equipment. In Canadian ice hockey, the implementation of a requirement for junior players to wear face guards was associated with a reduction in the proportion of eye injuries from 30% of all injuries in the 1974-1975 season to 7% in the 1978-1979 season (Hoskin et al., 2016). Meanwhile, in the American professional ice hockey league (NHL), the implementation of a mandate requiring new players to wear half-visors (from the 2013–2014 season onwards)

was associated with an immediate reduction in the incidence of eye injuries from 10 cases per year to zero (Rohowetz et al., 2025). An equally marked preventive effect was observed in the American women’s lacrosse league, where a nationwide requirement to wear goggles led to an 84% reduction in eye injuries and a 56% decrease in injuries to the facial skeleton. Importantly, no risk compensation effect – characterised by a secondary increase in the roughness of play – was identified (Shah et al., 2026). For racket sports such as squash or badminton, systematic reviews show that 93% of eye injuries are sustained by players without protective eyewear (Mazarelo et al., 2024). Importantly, severe ocular trauma remains undocumented in individuals utilising ASTM-compliant safety guards (Mazarelo et al., 2024).

6.3. Future Directions and Technological Challenges

Despite the proven effectiveness of polycarbonate protective eyewear, further product engineering remains essential to overcome behavioural barriers among users. A subjective sensation of a narrowed field of vision, aesthetic non-acceptance, low ergonomic comfort and the phenomenon of water vapour condensation on the lenses (fogging) are the main factors determining the decision not to use protective equipment during competition (Hoskin et al., 2016). The literature indicates that, whilst significant progress has been made in the industrial and military sectors in developing highly flexible and ergonomic frames, solutions designed strictly for athletes – particularly paediatric cohorts – still do not fully incorporate these innovations (Hoskin et al., 2016). The challenge for modern materials engineering is therefore to design solutions that not only pass ballistic tests flawlessly, but also optimise ventilation and usability, thereby maximising *compliance* with protective guidelines amongst athletes at all levels of proficiency (Hoskin et al., 2016).

Table 2. Effectiveness of systematic preventive interventions in reducing eye injuries (population data).

Sporting environment / Discipline	Type of intervention implemented	Epidemiological effect (Change in injury rates)
Canadian ice hockey (youth)	A top-down mandate to wear full-face visors (1974-1979).	This measure was associated with a reduction in the proportion of eye injuries from approximately 30% to approximately 7% of all injuries.
National Hockey	Mandatory use of half-visors	An immediate reduction in eye injuries

League (NHL, USA)	for new league players (from the 2013 season).	from 10 cases per year to 0 was documented.
Women's lacrosse (secondary schools, USA)	Nationwide regulations mandating the use of protective goggles.	An 84% reduction in eye injuries; no compensatory effect (increased roughness of play).
Racquet sports (systematic review)	Analysis of patient presentations to ED.	Approximately 93% of all victims were not wearing protective eyewear, and 0% of injuries occurred when certified (ASTM) equipment was used.

7. Barriers to the use of protective equipment – The athlete's paradox

Despite the widespread availability of certified eye protection and indisputable evidence of its high effectiveness in preventing injuries, the proportion of players who use it regularly remains extremely low. This phenomenon creates a peculiar paradox in sports medicine: eye protection is systematically and consciously marginalised by the players themselves. This attitude is attributed to a complex form of resistance rooted in ergonomic, visual, and sociocultural factors.

7.1. Ergonomic Barriers and Visual Impairments

The low rate of *compliance* with preventive recommendations stems primarily from direct functional barriers that, in the athletes' subjective assessment, negatively impact their performance (Hoskin et al., 2019). The primary reason for rejecting goggles and protective eyewear is the perceived narrowing of the field of vision, a key element of spatial orientation that determines the speed of motor decision-making on the pitch or court (Hoskin et al., 2019; Hoskin et al., 2016).

Athletes consistently point to the restriction of peripheral vision as a factor that impairs their situational assessment and their so-called 'feel for the game' (Hoskin et al., 2016). Additional ergonomic obstacles encompass physical discomfort associated with frame wear, thermal discomfort resulting from water-vapour condensation on lenses during exercise, reduced overall comfort, and financial burdens (Hoskin et al., 2019; Hoskin et al., 2016). Studies conducted among cohorts of racket sports players confirm that perceived inconvenience in use and fears of visual interference are the main obstacles to the widespread adoption of protective equipment (Aiello et al., 2026).

7.2. Psychological and Socio-Cultural Factors

Alongside purely ergonomic barriers, psychosocial factors and the deeply ingrained characteristics of sporting culture present an equally significant obstacle. In many sports, concerns about a deterioration in one's physical appearance and personal style remain a key factor influencing preventative behaviour (Hoskin et al., 2016). In sports characterised by a high level of physical aggression and tolerance for pain (e.g. ice hockey), players often choose not to wear appropriate protective gear for fear of stigmatisation, fuelled by the belief that such protective equipment is a sign of weakness (Hoskin et al., 2019). A similar problem affects mixed martial arts (MMA) competitors, where a prerequisite for the effective promotion of protective gear is that participants themselves and the sporting organisations overcome the strong social stigma (Ferretti et al., 2024).

Peer pressure plays a particularly destructive role amongst young athletes, effectively hindering the implementation of prevention programmes (Hoskin et al., 2016). Young athletes reject protective measures for fear of peer ostracism (ridicule), whilst displaying a carefree attitude towards the risk of vision loss (Yahalomi et al., 2025). In this age group, aesthetic concerns and a lack of acceptance of the appearance of spectacles are among the main psychological factors that reduce *compliance* (Yahalomi et al., 2025). The development of such risky attitudes is further fuelled by the media – in television programmes aimed at children, dangerous behaviour rarely results in injury, and the issue of eye protection equipment is completely marginalised (Hoskin et al., 2016).

In amateur sports disciplines that are rapidly gaining in popularity, there is also a tendency to downplay the risks to an extreme degree. Survey results show that a significant proportion of players show little interest in their own safety or adopt a completely indifferent attitude towards eye care (Aiello et al., 2026). The persistence of risky tendencies at competitive levels is further compounded by a lack of knowledge of injury prevention among those supervising training, including the coaches themselves (Ferretti et al., 2024). Consequently, it is not widespread education but rather the personal experience of a prior eye injury that is associated with a positive shift in attitudes and a greater willingness to use protective eyewear (Aiello et al., 2026). Despite such complex behavioural barriers, the literature on the subject suggests that athletes would demonstrate a significantly higher rate of acceptance of protective equipment if ergonomic, aesthetically pleasing and user-friendly equipment were more readily available to them (Moon et al., 2016).

8. Discussion and Methodological Limitations of the Available Studies

A key limitation and source of systematic bias in the available literature is the nature of the medical data collected (Zhang et al., 2023). Most multicentre epidemiological

analyses rely exclusively on national hospital emergency department (ED) registers, such as the US NEISS system (Ashraf et al., 2022; Boden et al., 2017; Shah et al., 2026). This methodology generates significant *selection bias*, as it systematically excludes patients with milder eye injuries who were treated on an outpatient basis, by club doctors, or who did not seek specialist medical care at all (Mysore et al. 2026; Moon et al., 2016; Shah et al., 2026). Consequently, the actual scale of ophthalmic injuries in the sporting population is systematically underestimated (Boden et al., 2017). Additional limitations are evident in studies concerning combat sports (including boxing and MMA). The published data in these studies often originate from ring doctors, who use highly general and imprecise descriptors of pathologies. Furthermore, diagnoses of serious injuries, such as fractures of the orbital structures, are largely based on an initial clinical assessment, without mandatory confirmation by computed tomography (CT), thereby reducing the reliability of the compiled statistics (Flitsos et al., 2021; Chang et al., 2024).

A key methodological shortcoming in the current state of knowledge, however, is the lack of *long-term follow-up* of patients. The vast majority of available studies are cross-sectional or retrospective, making it impossible to track the long-term outcomes of those affected (Zhang et al., 2023; Moe et al., 2023). This constitutes a critical obstacle to assessing the impact of injuries sustained on players' quality of life after their careers (Shah et al., 2026). The literature unequivocally indicates that long-term ophthalmological complications, such as secondary glaucoma developing against a background of post-traumatic angle recession (e.g., as a consequence of a microhaemorrhage) or recurrences of retinal detachment, may only manifest clinically many months or years after the initial impact (Boopathiraj et al., 2024; Iftikhar et al., 2021; Radtke et al., 2021). On the other hand, conditions initially considered to have a poor prognosis also require prospective assessment. An example is post-traumatic macular holes, which – unlike those of idiopathic aetiology – demonstrate the ability to close spontaneously and stabilise without the need for surgical intervention (Rohowetz et al., 2025). In the absence of long-term multicentre studies, the full extent of late complications, the degree of visual impairment and the resulting reduction in quality of life among former athletes remain impossible to estimate precisely (Ashraf et al., 2022; Zhang et al., 2023).

9. Conclusions and practical implications

Eye injuries sustained during sporting activities constitute a critical medical problem, leading, in a significant proportion of those affected, to a long-term reduction in quality of life (QoL), deterioration in visual function (QoV), and secondary difficulties in occupational functioning (Aiello et al., 2026; Ashraf et al., 2022). These conditions predispose

patients to long-term and chronic physical, psychosocial and economic burdens (Ashraf et al., 2022). From an epidemiological perspective, the consequences of these events are particularly severe in the paediatric population, where post-traumatic visual impairment affects the overall long-term personal and social development of young patients (Ashraf et al., 2022; Hoskin et al., 2016; Yahalomi et al., 2025).

The key conclusion of this review is the identification of a specific paradox in sports ophthalmology. Despite evidence that as many as 90% of sports-related eye injuries can be completely prevented with certified polycarbonate eye protectors, their use by athletes remains extremely low (Mazarelo et al., 2024; Zhang et al., 2023). The key barrier to effective prevention is therefore not technological shortcomings, but the psychosocially conditioned resistance of the players themselves. This resistance is attributed to perceived ergonomic inconveniences, visual field impairments, problems with water vapour condensation (fogging), and a fear of stigmatisation and negative perceptions of one's image (Aiello et al., 2026; Mazarelo et al., 2024).

Addressing this resistance requires real commitment from decision-makers and coaches. Above all, sports federations should consider mandating certified eye protection, starting with junior leagues (Mazarelo et al., 2024; Radtke et al., 2021). Scientific evidence unequivocally confirms the effectiveness of such measures: the introduction of a requirement to wear goggles in women's school field hockey leagues reduced the rate of eye injuries by over 50%, whilst the requirement for new players in the National Hockey League (NHL) to wear visors reduced the incidence of such injuries to zero (Boden et al., 2017; Rohowetz et al., 2025; Shah et al., 2026; Zhang et al., 2023). Concurrently, in combat sports (e.g. MMA), the establishment of precise guidelines for referees and ring doctors – promoting early bout termination and strict enforcement of periods of complete abstinence from contact training (*'no-contact time'*) following injury – is essential (Chang et al., 2024; Ferretti et al., 2024; Fliotsos et al., 2021). Systematic educational campaigns in which professional athletes (authorities) function as safety ambassadors (*role models*) are essential, as this approach has a proven impact on improving preventative attitudes among the youngest participants (Boden et al., 2017; Hoskin et al., 2019; Hoskin et al., 2016). Furthermore, the medical departments of sports clubs must ensure that pre-season ophthalmological examinations are carried out and equip doctors on duty at the touchline with specialist diagnostic equipment (including an ophthalmoscope, rigid shields and fluorescein tests), which is a prerequisite for the proper protection of the eye during the acute phase of an injury (Moe et al., 2023; Fliotsos et al., 2021). In view of the long-term psychological consequences of eye injuries, the integration of

physical rehabilitation with professional psychological and psychiatric support for those affected should also become standard practice (Mohseni et al., 2026; Aiello et al., 2026).

10. Main areas for future research (Future directions)

In order to effectively minimise the incidence of sports-related eye injuries, three priority areas are proposed for future scientific research and technological innovation:

10.1. Prospective analyses of long-term quality of life

The current literature is based primarily on retrospective emergency department records, which assess only the acute phase of injury and systematically overlook milder cases and long-term complications (Shah et al., 2026; Zhang et al., 2023). The key challenge for the scientific community is to design large- scale, prospective longitudinal (multi-year) studies. Only such a methodological approach will enable a reliable assessment of the extent of long-term impairment in subjective quality of life and visual parameters, as well as the identification of late complications emerging after retirement from sport (Aiello et al., 2026; Ashraf et al., 2022; Chang et al., 2024; Shah et al., 2026).

10.2. Standardisation of epidemiological registers

The creation of standardised, national registers of ocular injuries should become a priority for health policy. Existing databases do not require medical staff to record a key variable: the presence of protective equipment at the time of the incident (Ashraf et al., 2022). Refining reporting protocols will enable precise mapping of injury mechanisms and reliable verification of the effectiveness of preventive interventions (Hoskin et al., 2016; Zhang et al., 2023).

10.3. Interventional studies and optimisation of User Experience (UX)

To effectively increase players' willingness to wear protective equipment (*compliance*), the scientific community must collaborate closely with the materials engineering and biomechanics sectors. Future intervention studies should evaluate the acceptance, effectiveness and optical parameters of innovative equipment directly in match conditions (Aiello et al., 2026). The industry must strive to develop technologically advanced, dedicated solutions that improve the *user experience (UX)*. This call includes, in particular, the design of highly effective *anti-fog* systems and frames that closely fit the contours of the face (with particular attention to paediatric anatomy) (Aiello et al., 2026; Hong et al., 2024; Hoskin et al., 2016). The development of evidence-based guidelines for manufacturers is a prerequisite for creating equipment that will ultimately overcome the psychophysical barriers discouraging athletes from using protective gear (Aiello et al., 2026).

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Software: Kalina Kreft and Agata Sobczak

Validation: Anna Waldman and Magdalena Wolff

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Declaration of Generative AI and AI-Assisted Technologies in the Writing Process

In the development of this article, generative AI systems (Gemini, NotebookLM) were applied as supportive tools in two specific areas. Initially, they aided in the preliminary screening of the gathered literature to identify major thematic patterns. Subsequently, the tools were used for linguistic editing to improve the manuscript's academic English, optimizing grammar, flow, and overall clarity.

The authors declare that all AI applications were used strictly under human control and supervision. The critical analytical processes—including the final selection of references, literature interpretation, clinical synthesis, and the drawing of conclusions—remained the sole responsibility of human experts. Generative AI functioned purely to increase processing

efficiency and refine language, rather than to replace the researchers' independent judgment and critical analysis.

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