Paintball Eye Injuries: The Changing of an Industry

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Abstract
Serious eye injuries are the primary catastrophic injury from paintball, a game now played by over 7 million people, average age 16. To reduce injuries, players, manufacturers, sports officials, laboratories, insurance companies, and ophthalmologists joined forces to establish an eye injury prevention program that includes: (1) standards (field operation (ASTM F 1777), paintballs (ASTM F 1979) and protective eyewear (ASTM F1776); (2) a Protective Eyewear Certification Council (PECC); and (3) a Paintball Training Institute (PTI). No significant eye injuries have been reported in any of the approximately 1 million players who were wearing protectors that passed the ASTM F1776 standard and played on fields that conformed to the practice specifications of ASTM F1777. We believe that strict adherence to this prevention program will effectively eliminate paintball eye injuries to cooperating players and that paintball is eye-safe provided that the program is followed. There still are eye injuries when the markers are used without proper eye protection and in assault, such as drive-by shootings. Continued educational programs are necessary to reduce eye injuries that occur from inappropriate use of paintball markers.

Introduction
The purpose of this paper is to outline an injury prevention program that recognized a sports eye injury problem and implemented measures to reduce injuries.

Traditional firearms safety courses emphasize two absolute rules: always positively identify the target and never point a firearm (including an airgun) in the direction of any person, animal, or object other than the intended target (e.g., Sheets & Vinger, 1988). These firearm safety dogmas were violated when 12 friends used airguns that fired capsules—filled with paint and designed by foresters to mark trees for harvest—in a “survival game” where the participants were able to eliminate opponents from the game by shooting them with paint pellets.

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It soon became apparent that the paint capsules were responsible for blinding eye injuries. Players and field operators then began to use or distribute industrial safety, motorcycle, or ski goggles, despite the fact that these goggles were never tested for paintball and that industrial goggles have the warning that they are not designed for sports use (e.g. ANSI Z87.1-1989). This eyewear often failed, resulting in severe injury to players who had assumed they were protected.

As the sport grew, there was a slow shift in philosophy from “hunt and be hunted” to something like “capture the flag.” Tree-marking capsules, with indelible paint, were replaced by water-soluble “paintballs.” The paintball “gun” became a paintball “marker,” and a player who was eliminated from competition was “marked” rather than “killed.” Organized paintball is now a variant of “capture the flag” in which there are team objectives, and opponents are eliminated by being “marked.” Automatic markers, in which more than one paintball is discharged for one depression and release of the trigger, have almost totally been eliminated. Red paintballs (which may be confused with blood) are prohibited from many fields.

This change in philosophy opened up the sport to families, parent-sponsored party activities, and organized competition. In the past five years, the number of paintball playing fields and retail stores has increased from 1,200 to over 8,000 in the United States alone. The sport, having achieved global popularity, continues to grow at a rapid rate—from 12 participants in 1981 (e.g., Atwill, 1987) to 658,000 in 1988 to 5,923,000 in 1998 in the United States. Over 7 million men, women, and children in more than 40 countries have played paintball at least once in the preceding year (data supplied by Harvey Lauer, American Sports Data, Inc.).

At this time, the paintball mark is a non-toxic, water-soluble dye, contained in a spherical, usually gelatin capsule—the paintball (d 3.5g, 16.5-18.0mm diameter)—that is designed to break on impact. The paintball is propelled by an airgun, called a paintball marker, at a velocity not to exceed 91.4 m/s (300 ft/s, 204.5mph). Although participants normally wear protective clothing and safety equipment, if a direct impact of a paintball on the body does occur, it is moderately painful and results in bruising and localized hematoma, 2 to 3 cm in diameter. These welts are usually taken in stride by the player and are regarded as part of the game. However, the impact of a paintball on the unprotected eye is associated with severe injury. Pig eyes rupture when impacted with paintballs fired from closer than 4 meters (e.g., Vinger, et. al.,1997).

As paintball increased in popularity, eye injuries became apparent. Between 1984 and 2000, members of the Canadian Ophthalmological Society (COS) reported 78 paintball-injured eyes of which 33 (42%) were legally blinded. The COS data showed that the highest number of reported injuries occurred during the first year of reporting (1984) and that in the following years the rate of injury was significantly lower and stable. (Data collected by Tom Pashby, M.D., Toronto, Canada from members of the Canadian Ophthalmological Society) No eye injuries from paintball were reported to the Eye Injury Registry of Indiana from June 1992 to June 1996. Then, over the next two years 11 injuries were reported, representing 4% of all ocular trauma reports (e.g. Kitchens & Danis, 1999).

The paintball industry has become huge, but its initial growth was fueled by field operators and small manufacturers who were disorganized and unable to control the epidemic of eye injuries. In the early 1990s, the American Paintball League, the largest paintball insurance program with strict safety certification requirements, succeeded in significantly reducing eye injuries at its insured fields, (e.g. McGuire, 1992) but there were no safety standards or enforcement at most of the other paintball locations, and there were no standard specifications for safety equipment, especially eye protection devices. In 1994, the major insurer of paintball fields,
along with several manufacturers, distributors, paintball publications, and field operators who realized that they needed help, came to the American Society for Testing and Materials (ASTM), which has had an eye safety subcommittee within the main sports committee since 1975.

Thus, a cottage industry that had gone wild was exposed to the rigors of the voluntary consensus process. Under the umbrella of strict ASTM by-laws, ophthalmologists joined forces with manufacturers, insurance companies, lawyers, testing laboratories, field operators, game officials, players, and spectators to devise a program of prevention. The foundations of the prevention program were ASTM standards for paintball eye protectors (ASTM F1776) and field operation (ASTM F1777) and the formation of the Protective Eyewear Certification Council (PECC).

Method
We reviewed peer-reviewed publications for paintball eye injuries as related to the use of protective eyewear. Unpublished data (e.g., Schwartz, et. al., 2000) that almost equalled the total reported cases were also studied. Insurance companies were polled regarding claims for paintball eye injuries. The minutes of the eye safety (ASTM F8.57) and paintball (ASTM F8.24) subcommittees of the ASTM sports committee (ASTM F8), which reflected approximately 6 years in which standards were written according to the by-laws of ASTM were reviewed.

Results
Table 1 summarizes the published literature and the unpublished Schwartz data on paintball injuries related to protective eyewear. Eye injuries from paintball were often serious and were not prevented by eyewear initially used in the sport. The original eyewear typically used conformed to the Standard for Educational and Industrial Safety Eyewear (ANSI Z87.1-1989) which specifically states that the standard is not intended for sports. 132 of the 292 injured players possessed eyewear but either failed to put it on, lost it, had it dislodge during the game, or removed it because of scratching, fogging, cleaning, or to leave the game. Seven of those injured were not playing paintball—four were hit in drive-by shootings, two shot themselves while cleaning their markers, and one was shot by a young girl in a carnival game. Most of the eye injuries were severe and included hyphema, cataract, secondary glaucoma, retinal scarring, retinal detachment, and rupture of the globe of the eye. Two thirds of the injuries in the Fineman series and 37% of the injuries in the Schwartz series were legally blinded in that they had a final best-corrected vision of 20/200 or worse in the injured eye.

Eye protectors failed because the paintball dislocated the goggle lens from the frame, the goggles were dislodged by the force of the paintball that continued on to hit the eye, or the paintball entered through a side ventilation hole of industrial safety goggles. In all of the cases where goggles failed, the type of goggle used was not appropriate for paintball sports and would not be permitted under the current guidelines of the prevention program.

Since the prevention program began in 1997, there have been no reports of eye injury to any of the approximately 1 million players who played on cooperating fields and who were wearing a protector that conformed to the requirements of ASTM F1776-97. Those insurance companies who were polled, were unable to release comprehensive actuarial data, but we were assured that there were no claims for eye injury to any player who was wearing a protector that conformed to the requirements of ASTM F1776.
Discussion

The core of the prevention program was, and still is, the development and maintenance of ASTM standard specifications for paintballs, paintball markers, eye protective devices and standard practices for playing field behavior. The act of writing a standard often results in change before publication of the standard. After analysis, at an ASTM meeting, of the potential problems inherent in automatic paintball markers, the majority of manufacturers voluntarily stopped the manufacture and sale of markers that fired more than one paintball with one depression of the trigger.

The head and mask area are commonly “marked” because they are the primary exposed targets as players seek out their opponents. It is impossible to play the game without a substantial incidence of head and mask area contact by a paintball. Eye injuries cannot be prevented by rules changes, changes in the paintball, or changes in the paintball marker. Effective eye protection is therefore essential. Paintball has very specific requirements for eye protection, which are met only by sports protectors conforming to the requirements of ASTM F1776 (Figure I), the standard specification for eye protective devices for paintball sports. The standard includes requirements for optics, visual field, resistance to failure on impact, and resistance to paintball components entering the eye area. Because paint splatters through even the tiniest ventilation opening, it is not possible to avoid all contact of paint with the eye. Indirect paint splatter has little residual energy and the paint is not corrosive. This is not considered a significant injury risk, and the standard allows paint (but no shell fragments) to contact the eye. Manufacturers are working to minimize the factors causing players to remove goggles during the game. Fogging is controlled by better anti-fog agents, double-lensed protectors, and in-the-protector ventilation fans. On certain models, a fresh, clean front lens surface may be achieved by peeling off thin layers of sheet plastic that may be applied to the basic protector lens anterior surface before the game.

Figure 1. A PECC certified paintball eye protector.
Note that the protectors protect the ears and temples (e.g. Fox, et. al., 1994).
Taken in large part from the paintball field insurance program mentioned above, the Standard Practice for Paintball Field Operation, ASTM F1777, set forth procedures for operating a paintball playing field to assist paintball operators in running a safe business. The standard specifies the posting of safety rules, conspicuous signs to contain paintball firing to specific areas of the field, and a safety briefing to every player. Every field must have emergency contingency plans and a first aid kit readily available. The players must have the muzzle velocity of their paintball markers checked with a chronograph, must have barrel plugs in the markers when out of the designated area of chronographing or play, and must wear eye, ear and face protection when in an area where paintballs may be fired. At least one referee per every 15 players is mandatory, with a minimum of two referees for outdoor games. Areas designated for spectators and areas where players are not required to wear goggles have barriers to prevent paintball entry.

The standard ASTM F 1979-99 for paintballs specifies that they be water-soluble and non-toxic, and that the contents shall not cause chemical burns to the skin or the eye (pH 4.5 - 7.5). Paintballs also have specifications for weight (≤ 3.5g), diameter (16.5-18mm), and shell strength (10 of 10 balls fired horizontally onto a plywood target from 80 feet shall break upon impact). The paintball standard is being reviewed with a proposal to eliminate the color red, which may be confused with blood.

Specifications for Paintball Marker Warnings (ASTM F 2041-00) and Paintball Cylinder Burst Disk Assemblies (ASTM F 2030-00) have been completed. Standards for the paintball marker and barrel plugs, and safe procedures for filling the marker compressed air cartridge are in draft form. The marker standard will address the rate of fire, the elimination of automatic (more than one paintball discharged with one pull of the trigger) markers, trigger pull force, resistance to discharge from jarring, and other safety issues.

To assure the consumer that the eyewear used has been tested to ASTM F1776 by a laboratory accredited by the American Association of Laboratory Accreditation (A2LA), and that the manufacturer has appropriate quality control, the Protective Eyewear Certification Council (PECC) began certifying eyewear to ASTM F1776 in June, 2000. The majority of manufacturers of paintball protective eyewear participate in PECC (www.protecteyes.org). When the PECC seal for paintball (Figure 2) appears on a protector, one can be assured that protectors of this design by this manufacturer have been tested and that the protector design meets minimum requirements.

![PECC Seal](image)

Figure 2. Protective Eyewear Certification Council (PECC) seal that certifies the protector complies to ASTM F1776-97 requirements.

Current and future paintball players must keep in mind that paintball, like any other physical activity, such as riding a bicycle or playing tennis, presents a potential for injury. No procedural practice, protective device, or standardization of equipment can prevent all injuries—especially when participants do not follow safety instructions. Although great strides in rules, protective eyewear, and the standardization of equipment have the potential of effectively eliminating eye injuries in paintball, it is apparent that the ultimate responsibility for preventing injury lies with the paintball player.
Recognizing that many players purchase their equipment at mass merchant locations and may never have the opportunity to receive a safety briefing at an organized professional paintball playing field, the Paintball Training Institute (PTI), an industry supported training program, has trained over five hundred instructors in the USA to teach paintball player safety to new game participants. PTI (www.paintball-hti.com) distributes paintball safety videos and coordinates safety education classes nationwide. Safety class graduates receive a certification card, which enables them to purchase propellant gas fills for their paintball markers, at many dive shops and paintball stores. The non-profit web site www.paintball.org lists all players who have successfully completed the paintball safety class.

Commercialized paintball games have a greater use of protective eyewear and are safer than “backyard games.” (e.g. Fineman, et. al., 2000) While this program should eliminate essentially all eye injuries to players who wear eye protective devices and follow the playing field guidelines, there still will be eye injuries from paintball. Drive-by shootings, harassment, the use of alcohol and other drugs while playing, and irresponsible play without eyewear will be impossible to eradicate completely. However, we believe that many players can be diverted to safe fields with an educational campaign, which should include clear safety instructions, and a clear video emphasizing proper play conduct and safety rules. In addition, all retail stores should encourage the sale of paintball masks along with markers.

References


ASTM American Society of Testing and Materials. 100 Barr Harbor Drive. West Conshohocken, PA 19428-2959.


