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Reducing Head Injuries In Soccer White Paper

February 2003

Introduction

The popularity of soccer is unquestioned. Also unquestioned is that head injuries occur in soccer.

Protection against head injuries is complicated by the fact that heading is an established part of the game, and any attempt to protect against head injuries must allow the game to be played without modification.

While the act of heading had not been proven to cause concussions, the result of years of heading is still under debate. Other types of impacts – head to ground, head to goal post, head to another player – are known to cause concussions and there may be long term negative effects as well. Any protection offered to players must mitigate these incidental impacts while not altering the method or result of heading.

Several products have been developed to reduce the risk of head injuries in soccer. One independent research study found that none of the products on the market provided significant benefits against minor impacts with a soccer ball i.e. heading. Other tests show that at least one available product provides important protection against both rotational and linear acceleration in more severe impacts such as incidental impacts, including collisions with a goal post or another player. In many cases, concussive-level impacts are reduced to sub-concussive levels when the headguard is worn, with reductions of upwards of 50% to both linear and rotational acceleration in impacts typical in soccer.

The results of testing for Full90 Performance Headguard™ show conclusively that head protection can be provided in soccer without changing the game.

Soccer organizations have chosen to overlook the issue of head injuries in soccer, so to-date there is little discussion of the issue. However, the problem still remains and a viable solution is available.

Headguards are a sensible solution that should be considered for use in soccer at the option of a player and/or their parents.

Is there a head injury problem in soccer?

There are head injuries in soccer and some of them are quite severe. Attend just about any competitive tournament during the season, and you will see a sports medicine tent staffed by emergency medical personnel. It is common for them to attend to at least one head injury during each tournament – usually a concussion-type injury.

The U.S. Consumer Product Safety Commission collects data on injuries in all sports, and recent figures from them estimate that there are thousands of soccer-related concussions in the US every year. Over the past eight years, the rate of concussions has grown nearly twice as fast as the rate of growth of soccer players, according to data from SGMA (Sporting Goods Manufacturers Association) and CPSC. Because of the difficulty and confusion surrounding the diagnosis of concussions, these numbers are only estimates, but they point out clearly that head injuries in soccer are a growing concern.

Dr. Delaney et al[1] at McGill University found that more than 60% of college-level soccer players reported symptoms of concussion (headache, nausea, dizziness, amnesia, light sensitivity, etc) during a single season. Although the percentage at other levels of play may be different, these data indicate that head injuries in soccer are more frequent than most suspect.

[1]Delaney JS, Lacroix VJ, et al., "Concussions Among University Football and Soccer Players," Clin J Sport Med 2002;12(6):331-8

How are concussions in soccer caused?

According to US CPSC data[2] , reported concussions in soccer are caused by:

- 40% - Head to Player Contact
- 10.3% - Head to ground, goal post, wall, etc...
- 12.6% - Head to soccer ball (including accidental impacts)
- 37% - Not specified

The Impact of Concussions

What is a concussion?

A concussion is a trauma-induced change in mental status, with or without unconsciousness. It may be caused by an impact to the head or upper body, or by non-contact severe motion, such as whiplash.

What forces are at work to cause a concussion?

There are two types of forces at work in impacts that lead to a concussion.

1. Linear Force
2. Rotation Force

Linear acceleration is the force felt when a body is pushed without any twisting or tilting. A wind that blows directly onto your back exerts a force that is almost entirely linear, because it pushes your body without twisting it. The brain is not compressible, so a linear force tends to simply push the skull and brain in the same direction.

Rotational acceleration is the force a body feels when it is struck a glancing blow that tends to turn or tilt the body. Someone bumping into one of your shoulders from behind generates a rotational force on your body by trying to turn it. The differential between the skull and the brain may cause the brain to rotate within the skull. Rotational forces are thus more potentially damaging to the brain than linear forces.

What is the result of a concussion?

It may be as minor as a fleeting headache, or as severe as prolonged unconsciousness. Between these two extremes are such symptoms as nausea, dizziness, vertigo, heightened sensitivity to light or sound, amnesia, change in sleep patterns, blurred vision, ringing in the ears, mood changes, and short-term unconsciousness.

Another issue is that of repeated concussions within a fairly short time frame. It is currently believed that a person who has had one concussion is four to six times as likely to have a second concussion as a non-concussed player. The second concussion is often significantly more severe than the first, even if the second impact is seemingly minor, because the brain has not completely healed from the first concussion yet. Most of these cases (referred to as second impact syndrome, or SIS) are unreported because they are not recognized as the results of repeated concussions.

[2]CPSC, "Soccer Head Injuries, Calendar Year 1995 to 11-30-02," National Electronic Injury Surveillance System (NEISS)

Measuring Impacts

Does a person need to be concerned about turning their head to look at someone? Do they need to worry about someone tapping them on the head with a pencil?

No, the forces must be more significant than that.

When you stand still on the floor, there is pressure on your legs because they are supporting your body weight. Because the force holding you down is just gravity, the force felt by your legs is one gravitational unit, or 1 g. If you are in an elevator that begins rising, you momentarily feel more pressure on your legs because of the upward movement – you're feeling more than 1 g.

It has been demonstrated [3] quite accurately that concussions may occur in humans at linear accelerations of about 78 g. This is approximately the force you would feel if a professional boxer hit you with a right hook directly into your ear.

Rotational acceleration is more difficult to understand and measure, and is only now beginning to be addressed seriously. Although estimates vary dramatically, it is likely that a rotational acceleration of about 4,800 rad/sec2 results in a 20% probability of concussion.

Because the head is tied to the body by the neck, it is almost impossible for an impact to the head to have only linear acceleration or only rotational acceleration. The head cannot move linearly unless the entire body moves linearly; most forces tend to make the head rotate on the neck as well as move laterally, although the ratio of linear to rotational can vary.

Since most impacts contain both kinds of forces, one must combine the forces to determine an overall threshold for concussion. The scientific term that has been calculated is GAMBIT [4] – Generalized Acceleration Model for Brain Injury Threshold. Dropping a headform in freefall onto a steel plate from a height of about 16 inches results in a GAMBIT of about 0.95 – a GAMBIT of 1.0 means almost certain death, so this impact would be fatal to most people.

Results of Full90 Performance Headguard™ Testing

Full90 Sports has conducted testing of the Full90 Performance Headguard™ under realistic circumstances, with meaningful results. At two prestigious independent laboratories Full90 Sports, Inc conducted testing of the headguard in head to ball, head to head, head to knee, and head to goal post impacts.

Results from North Dakota State University by Dr. Mariusz Ziejewski

Experiments conducted at NDSU Impact Biomechanics laboratory tested whether a head to ball impact may be adequate to cause injury, if the head is unprepared for impact, as opposed to deliberate heading.

[3] Newman JA, Barr C, et al., "A New Biomechanical Assessment of Mild Traumatic Brain Injury. Part 2 – Results and Conclusions," International Conference on the Biomechanics of Impact (IRCOBI), 1999.

[4] Newman JA, "A Generalized Acceleration Model for Brain Injury Threshold (GAMBIT)," International Conference on the Biomechanics of Impact (IRCOBI), 1986.

Dr. Ziejewski[5] performed computer simulations based on impact data, and determined that:

- Ball impacts can cause concussion if head is not prepared for impact.
- Impact forces can be reduced by protective padding
- Full90 reduced strain on brain by 50%, stretching of brain tissue by a factor of ten, and volume of brain affected by impact by 24%
- Linear acceleration in a heading incident, although not sufficient to cause injury by itself, was reduced by 40% by Full90 in typical collisions.
- The rebound speed of the ball from a Full90-covered head is the same as the rebound speed from a bare head – there is no impact on the game.

In 2002, Full90 Sports undertook additional testing at North Dakota State University, with emphasis on incidental impacts and the repeatability of performance of the product. Results of these tests will be available sometime in 2003.

The NDSU Impact Biomechanics Lab in Fargo, North Dakota, is directed by Dr. Mariusz Ziejewski, an international leader in computer simulation and analysis of head impacts. Dr. Ziejewski is recognized world-wide for his work in relating experimental head impacts to the severity of injuries in humans. The NDSU lab has conducted a number of studies for the United States Air Force, as well as many proprietary projects for commercial endeavors. Dr. Ziejewski is the individual who determined that impacts of a soccer ball to a head can have sufficient force to cause mild traumatic brain injury, particularly if the head is unprepared for the impact.

[5]Ziejewski M, et al., "A Biomechanical Examination of the Efficacy of Soccer Protective Headgear in Reducing Trauma to the Head from Low Impacts," 1999 (Unpublished).

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Results from Dr. Terry Smith of Dynamic Research

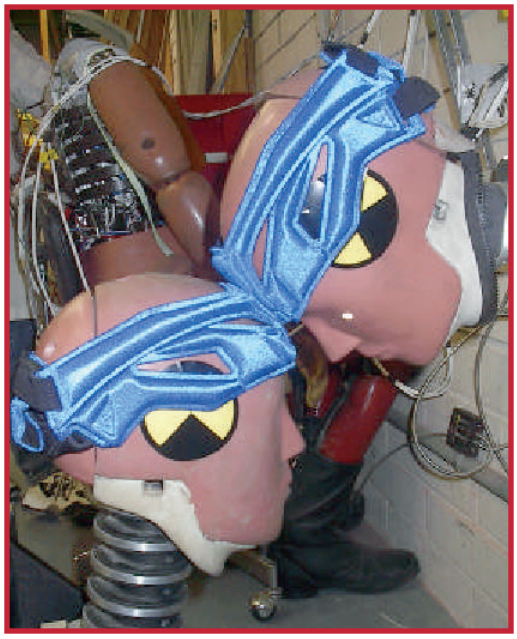
Experiments conducted tested the incidental, or accidental, impacts common in soccer, including head to head, head to goal post, and head to knee. The impacts were designed to create approximately the same levels of impact as occur in a soccer match.

Dr. Terry Smith[6] conducted research using Hybrid III dummies, the best instrumented and most humanlike dummies available, and concluded that:

- Some incidental impacts, such as head/goal post, are sufficient to cause concussion solely through linear acceleration.
- Use of the Full90 Performance Headguard™ product on a standard test head in a typical head/goal post impact reduces the linear acceleration by 50% to a sub-concussive level.
- Use of Full90 Performance Headguard product on the head and on the goal post (to simulate a padded goal post) reduces the linear acceleration by 2/3.
- In head to head impacts, rotational acceleration, the most important factor in concussions, between two bare heads generated rotational acceleration of 7750 rad/sec2, (In all cases of rad/sec2, change to rad/sec2) about 50% greater than the estimated threshold for concussion.
- With a Full90 Performance Headguard on one head, the rotational acceleration was reduced to the sub-concussive level of 3600 rad/sec2.
- When Full90 Performance Headguards were worn by both heads, rotational acceleration was only 2200 rad/sec2 – less than 1/3 the unprotected level.

Forehead to forehead impact in freefall drop of 50 cm (about 20 inches):

- With both heads bare, GAMBIT = 0.35 (~32% probability of concussion)
- With one head wearing Full90, GAMBIT = 0.21 (~3% probability of concussion)
- With both heads wearing Full90, GAMBIT = 0.14 (~1% probability of concussion)



[6]Smith, TA, "DRI Test Report 164-2," January 2003.

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Forehead to goal post impact in freefall of 30 cm (about 12 inches):

- With both objects bare, GAMBIT = 0.81 (~99% probability of concussion)
- With Full90™ on headform, GAMBIT = 0.34 (~30% probability of concussion)
- With Full90 on head and goal post, to simulate padded goal post, GAMBIT = 0.16 (~2% probability of concussion)

Dynamic Research, Inc. (DRI) operates one of the most advanced dynamics and biomechanics laboratories in the world. They specialize in development, applied research, and consulting in such areas as vehicle dynamics and control, human factors and ergonomics, simulator technology and structural mechanics as they relate to the design and testing of wheeled vehicles. Through their work with all major vehicle manufacturers, they have acquired the expertise and sophisticated equipment to measure both linear and rotational acceleration in the human head. DRI's capability in software development ensures the most advanced analysis of the raw data obtained in experiments. DRI, founded in 1979, utilizes Hybrid III dummies, the best instrumented and most humanlike dummies available, to create the most appropriate experiment dynamics. Dr. Terry Smith, our technical contact, has over fifteen years experience in analyzing head protection products.

Conclusions

It is undeniable that incidental head impacts resulting in injury occur in the competitive game of soccer. Now there is a proven product designed to reduce the risk of those head injuries without changing the game.

Full90 Performance Headguards™ provide significant protection to the head of the wearer, and to the bodies of others who may collide with the wearer's head. No headgear can protect against all impacts, and serious injuries may occur even when Full90 Performance Headguards are worn correctly. However, these data prove conclusively that Full90 Performance Headguards offer significant head protection from the kinds of impacts that occur commonly in soccer.

The philosophy of Full90 Sports is that soccer players should take all reasonable precautions to protect themselves against potential injury caused by incidental and intentional impacts to the head. Full90

Performance Headguards™ are produced with that philosophy in mind. Full90 Performance Headguards work, are simple and comfortable to use, and they do not change the game.

Research and development efforts are continuing, as Full90 Sports strives to provide the best, most useful head protection. At the same time, so too are efforts to educate players, parents, coaches, referees, and soccer organizations about the risks of both acute and long-term head injuries. The goal of Full90 Sports, Inc is to provide products to as many developing players as possible, to increase the likelihood that the next generation of soccer players will be even more refined and skilled as well as better protected. Full90 is not advocating that head protection be mandated for all soccer players; only recommending that it be left up to discretion of players and/or parents. Soccer is an excellent game and Full90 Sports is doing its part to ensure the future success and safety of the sport of soccer.

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