The Role of Synthetic Turf in Concussion

Introduction

As evidence of the serious consequences of concussion and repetitive brain trauma grows, the search intensifies for new methods of concussion prevention and mitigation. When it comes to the role of equipment and padding, helmets, headgear, and mouth guards dominate the conversation. One opportunity to reduce risk that is consistently overlooked is the role of the playing surface, and particularly the opportunity to reduce concussion risk by providing safer fields.

1 in 5 concussions is caused by a head to surface impact

In a study of a nationally representative high school population, 15.5% of concussions across multiple sports occurred as a result of contact with the playing surface.[1] An additional 6% of concussions were caused by secondary head to turf impact after a player to player impact.[1] The CDC estimates that between 1.6 and 3.8 million concussions occur in sports and recreation every year.[2] Therefore, contact with the playing surface may account for between 350,000 and 817,000 concussions per year in the United States.

The share of concussions caused by contact with the surface varies by sport and age. In a study of high school and college football players, contact with the playing surface was implicated in 10% of all concussions.[3] In soccer, Comstock[4] reported that 13.3% of concussions in boys high school soccer and 19.2% of concussions in girls high school soccer resulted from head to surface impact. In 5–19 year olds in Canada, Cusimano[5] found 17.5% of all soccer related concussions and 11.5% of all football related concussions resulted from head to surface impact.

Study	Sports	Ages	Concussions from Surface Impacts
Comstock et al, 2015	Soccer	High School	19.2% (Girls) 13.3% (Boys)
Guskiewicz et al, 2000	Football	College High School	10.0%
Cusimano et al, 2013	Soccer Football	5–19	17.5% 11.5%
Meehan et al, 2010	Football Soccer (Boys + Girls) Basketball (Boys + Girls) Wrestling Baseball Volleyball Softball	High School	15.5%

Table 1: Proportion of concussions by surface impacts across studies

Youth athletes are at greatest risk

The risk of concussion posed by surface conditions is elevated at the youth level. Data from the Canadian Hospitals Injury Reporting and Prevention Program found that 27.3% of soccer and 25.9% of football concussions in children aged 5-9 occurred from surface impacts.[5] Biomechanical and developmental differences between younger and older youth athletes may provide insight into the data. A child's head mass as a proportion of total body mass peaks at birth and slowly declines over time. At age 6, a child's head is almost 90% adult size, while their body mass is only 20% of their adult size. Event at age 12, a child's head size is 95% of adult size, yet their overall mass is less than 50% of adult size.[6] In addition, neck musculature is less developed, leading to a "bobblehead doll" effect and a child's inability to prevent their head from striking the ground when they fall. Concussion in youth is an area of great concern, as studies have shown that that the consequences of concussion in the young developing brain are potentially more damaging than in the adult brain.[7]

Artificial turf fields see considerable use

In 2013, there were over 11,000 synthetic turf fields in use, with 1,200 installed that year alone.[8] Additionally, these fields see considerably more use than natural grass fields, with some reports indicating some fields see ten times as much use as natural grass fields, upwards of 4250 hours per year.[9] As athletes play more and more on these synthetic field turf systems, it is important to investigate and understand how this technology can affect injuries.

Turf field conditions could impact concussion risk and severity

There have been very few direct empirical comparisons of concussion risk on grass and artificial turf fields, and those limited investigations have produced varied findings.[3,10-16] The relationship between an artificial turf field and concussion comes down to the ability of the surface to attenuate impact forces. With a harder surface, less of the impact forces can be absorbed by the material and are instead are absorbed by the athlete's head. In synthetic tuft systems, the utilization of different component types can affect impact attenuation properties, with some component selections offering greater impact attenuation than others.[8]

Compared to natural grass, exceptionally well maintained artificial turf can perform similarly to natural turf across a variety of measurements.[17,18] In a helmet drop-test study directly comparing artificial turf fields with both cryo and thermoplastic infill and natural turf at an elite college sports program, artificial systems performed comparably to natural turf, although natural turf consistently attenuated impacts more than artificial turf.[18] Williams[17] also reported that natural turf consistently attenuated fall impacts better than third and fourth generation artificial turf systems, requiring greater fall distances to achieve rebound forces associated with concussion risk.

Turf field components and conditions can degrade over time and require regular maintenance

With regard to concussion, the protective characteristics of an artificial turf field have been found to degrade as the field sees more use.[9] From a structural perspective, the choice of components, including the foam under pad, can significantly alter impact attenuation.[19] Further, in fields using rubber infill, a popular design among newer turf fields, significant compaction can occur further decreasing impact attenuation in areas of the field that are more frequently used.[20] Decreased impact attenuation could increase the amount of force transferred to an athlete's head during a fall, potentially increasing their risk of sustaining a concussion.

While it is generally recommended turf be evaluated for firmness every year, few comply with the rule, and athletes play on turf that may be out of compliance.

Conclusion

Concussion prevention and mitigation is now a priority across all sports. There are no silver bullets when it comes to preventing concussion, and every opportunity to reduce risk must be explored. Currently, there is limited data on how much any one piece of athletic equipment may impact risk of concussion. Even with football helmets, an area of intense focus, recent field studies have not shown any specific brand or model of helmet to be more protective against concussion than another.[21]

Artificial surfaces should receive the same attention and scrutiny as football helmets. Despite one in seven high school sports concussions being caused by surface impacts, and one in four concussions in youth soccer and football, we have no national conversation on the technology underneath an athlete's feet. Helmet technology is an area of great attention and investment, and surfaces deserve the same attention.

About the Concussion Legacy Foundation:
The Concussion Legacy Foundation (formerly the Sports Legacy Institute) is a 501(c)(3) non-profit organization located in Boston, Mass. It was founded in 2007 by Dr. Robert Cantu and Christopher Nowinski to solve the concussion crisis by advancing the study, treatment, and prevention of the effects of brain trauma in athletes and other at-risk groups. For more information, please visit ConcussionFoundation.org. Chris Nowinski, Clifford Robbins, Peter Schade, and Dr. Robert Cantu contributed to this report.

Disclosures: The Concussion Legacy Foundation receives funding from Brock International

References

[1] Meehan WP III, d'Hemecourt P, Comstock RD. High school concussions in the 2008-2009 academic year: mechanism, symptoms, and management. Am J Sports Med. 2010 Dec;38(12):2405-9.
[2] Langlois JA, Rutland-Brown W, Wald MM. The epidemiology and impact of traumatic brain injury: a brief overview. J Head Trauma Rehabil. 2006 Sept-Oct;21(5): 375-8
[3] Guskiewicz KM, Weaver NL, Padua DA, Garrett WE Jr. Epidemiology of concussion in collegiate and high school football players. Am J Sports Med. 2000 Sep-Oct;28(5):643-50
[4] Comstock RD, Currie DW, Pierpoint LA, Grubenhoff JA, Fields SK. An evidence-based discussion of heading the ball and concussions and high school soccer. JAMA Pediatr. 2015 Sep 1;169(9):830-7
[5] Cusimano MD, Cho N, Amin K, Shirazi M, McFaull SR, Do MT, Wong MC, Russel K. Mechanisms of team-sport-related brain injuries in children 5-19 years old: opportunities for prevention.
[6] Bradtmiller B, and Kristensen S (1994) The Development of a 3-D Data Base of Head and Facial Anthropometry for Children and Youths .Final Report. Prepared under contract to George Snively Research Foundation, Hobbs, NM.
[7] Daneshvar DH, Nowinski CJ, McKee AC, Cantu RC. Epidemiology of sport-related concussion. Clin Sports Med. 2011 Jan;30(1):1-17.
[8] Synthetic Turf Council. About synthetic turf fields. http://www.syntheticturfcouncil.org/?page=Sports_Fields. Accessed September 1, 2015.
[9] Gert-Jan Kieft. Quality monitoring of 50 artificial turf football fields: correlation between field properties, usage, and maintenance. Presented at SportSURF workshop, March 4 2009.
[10] Meyers MC. Incidence, mechanisms, and severity of match-related collegiate women's soccer injuries on FieldTurf and natural grass surfaces: a 5-year prospective study. Am J Sports Med. 2013 Oct;41(10):2409-20
[11] Meyers MC. Incidence, mechanisms, and severity of game-related college football injuries on FieldTurf versus natural grass: a 3-year prospective study. Am J Sports Med. 2010 Apr;38(4):687-97
[12] Dragoo JL, Braun HJ. The effect of playing surface on injury rate: a review of the current literature. Sports Med. 2010 Nov 1;40(11):981-90
[13] Fuller CW, Dick RW, Corlette J, Schmalz R. Comparison of the incidence, nature and cause of injuries sustained on grass and new generation artificial turf by male and female football players. Part 1: match injuries. Br J Sports Med. 2007 Aug;41 Suppl 1:i20-6
[14] Fuller CW, Dick RW, Corlette J, Schmalz R. Comparison of the incidence, nature and cause of injuries sustained on grass and new generation artificial turf by male and female football players. Part 2: training injuries. Br J Sports Med. 2007 Aug;41; Suppl 1:i27-32
[15] Meyers MC, Barnhill BS. Incidence, causes, and severity of high school football injuries on FieldTurf versus natural grass: a 5-year prospective study. Am J Sports Med. 2004 Oct-Nov;32(7): 1626-38
[16] Hagel BE, Fick GH, Meeuwisse WH. Injury risk in men's Canada West University football. Am J Epidimiol. 2003 May 1;157(9):825-33
[17] Williams S, Hume PA, Kara S. A review of football injuries on third and fourth generation artificial turfs compared with natural turf. Sports Med. 2011 Nov 1;41(11):903-23
[18] Viano DC, Withnhall C, Wonnacott M. Football helmet drop tests on different fields using an instrumented Hybrid III head. Ann Biomed Eng. 2012 Jan;40(1):97-105
[19] Naunheim R, McGurren M, Standeven J, Fucetola R, Lauryssen C, Deibert E. Does the use of artificial turf contribute to head injuries? J Trauma. 2002 Oct;53(4):691-4
[20] Naunheim R, Parrott H, Standeven J. A comparison of artificial turf. J Trauma. 2004 Dec; 57(6):131-4
[21] McGuine TA, Hetzel S, McCrea M, Brooks MA. Protective equipment and player characteristics associated with the incidence of sport-related concussion in high school football players: a multifactorial prospective study. Am J Sports Med. 2014 Oct;42(10):2470-8.