

Summary of Testimony of Dr. R. Dawn Comstock for the U.S. House of Representatives' Committee on Energy and Commerce, Subcommittee on Oversight and Investigations hearing entitled "Concussions in Youth Sports: Evaluating Prevention and Research." Friday, May 13, 2016

- 1) There have been vast improvements in our knowledge of youth sports-related concussions over the past decade.
- 2) Sports are an important way for children to incorporate physical activity into a healthy lifestyle and parents should not be afraid to allow their children to play sports but it is imperative to make concussion prevention specifically and athlete health and safety in general a priority.
- 3) To date the majority of federally funded concussion work has focused on improving concussion diagnosis, improving management of concussed athletes, and improving our understanding of the long term negative health outcomes associated with concussion – all of which are important, but none of which reflect primary prevention efforts. It is time to shift the focus to primary prevention.
- 4) Effective concussion prevention efforts will need to be sport-specific, targeted, evidence-based, and multi-faceted.
- 5) We do not currently have any national sports injury surveillance programs capable of providing the information required to drive such prevention efforts for athletes younger than high school aged.

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Chairman Murphy I am honored to testify on the important topic of youth sports-related concussions before the Committee on Energy and Commerce’s Subcommittee on Oversight and Investigations today. It is with pride that I represent the Colorado School of Public Health as a constituent of the ranking member of the committee, Congresswoman DeGette.

As the Director of The National High School Sports-Related Injury Surveillance Study, more commonly (and more easily) referred to as High School RIO, I have spent my entire career attempting to improve young athletes’ health by providing the evidence needed to make sports as safe as possible (see Appendix 1). I was asked to attend today’s hearing to share the current state of research in the area of youth sports-related concussion. First I must note how much has improved over the past decade. When I established High School RIO in 2005 concussions were not yet resonating as a concern among parents of young athletes. Injured athletes were frequently said to have had their “bell rung” or to have been “dinged” and sports-related injuries, including concussions, were considered by most parents to be unavoidable, “just part of the game,” or “the price you have to pay to play.” Much has changed. Massive media attention, state level legislative efforts, and educational efforts by numerous organizations occurred concurrently with, and in fact were at

times driven by, great advancements in our understanding of the rates and patterns of concussion among high school athletes. I'll highlight a few advancements in our knowledge using examples from my High School RIO dataset.

1) Ongoing surveillance efforts have demonstrated a rapid increase in concussion rates over the past decade (see Appendix 2). Most believe this increase reflects better diagnosis and capture of concussion injuries rather than a true increase in the numbers of concussions. Encouragingly, surveillance data from the past few years demonstrates concussion rates have leveled off. However, continued surveillance is needed to monitor these ongoing trends.

2) Concussion rates vary by sport, gender, and type of athletic activity (see appendix 3). For example, first in terms of sport-specific differences, football has the highest rates of concussion in both competition and practice with other full contact sports (boys' ice hockey and lacrosse) also among the four sports with the highest rates. Many are surprised to learn girls' soccer has consistently had competition concussion rates as high as or higher than these boys' sports. However, practice is a different story. Cheerleading, which has a low competition/performance concussion rate relative to other sports has the second highest practice concussion rate. Conversely, boys' ice hockey has a low practice concussion rate relative to other sports. Second, in gender comparable sports girls have significantly higher concussion rates than boys. Finally, in nearly every sport, competition concussion rates are significantly higher than practice concussion rates. Understanding such differences is

essential as it demonstrates that concussion prevention efforts can't be "one size fits all." Rather effective, targeted prevention efforts must be evidence-based and sport-specific.

3) Improvements have been made in management of concussed athletes (see appendix 4). In 2007/08, over 30% of high school athletes diagnosed with a concussion returned to play within a week of their injury which is premature according to accepted return to play guidelines and, disturbingly, 8% were allowed to return to play the day they were injured. Following massive educational efforts by the National Federation of State High School Athletic Associations (NFHS), the Centers for Disease Control and Prevention's National Center for Injury Prevention and Control, and others we have observed very positive trends. Last academic year (2014/15) less than 10% of high school athletes diagnosed with a concussion returned to play within a week of their injury and less than 2% returned to play the day they were injured. These are encouraging trends indications the parents, coaches, and clinicians of young athletes are now all much more aware of the signs and symptoms of concussion, the importance of removing an injured athlete from play, and the need for an injured athlete to be kept out of play until released to return by an appropriate health care advisor.

At this point I feel it is important to note that I am not against sports, even contact sports. I don't want parents to be afraid to allow their children to play sports. We have an epidemic of obesity in our country and playing sports is a great way for our youth to incorporate daily physical activity into a healthy lifestyle.

Despite our current concern over concussions, the negative effects of an inactive lifestyle (e.g., diabetes, heart disease, etc.) are more concerning due to their relatively high likelihood compared to the very small likelihood that any individual child will sustain a serious sports-related injury resulting in life-long problems. Additionally, while you may have difficulty envisioning this looking at the middle aged, 4'11", slightly overweight woman sitting before you, I was a three-sport athlete at Centennial High School in Pueblo Colorado and as an undergraduate at Colorado State University I began playing rugby, a sport I pursued for 13 years. I learned about work ethic, teamwork, commitment, etc. from playing sports and because of my time playing rugby I recognize the sense of accomplishment and adrenalin rush one gets when you make a good tackle and I appreciate the life lessons embodied in picking yourself up and returning to play after being tackled. I understand that the culture of full contact sports must be respected if we are to make any progress toward concussion prevention. However the time has come and past for the adults involved in youth sports – the parents, coaches, administrators, educators, researchers, clinicians, policy makers, and regulators – to recognize that keeping young athletes as safe as possible must be made a priority and will only be effective if approached as a team effort.

With this in mind, I want to extend particular thanks to this committee for holding a hearing focused on prevention. When I was asked to present a researcher's view of the current state of concussion prevention I realized the importance of briefly noting the differences between primary, secondary, and tertiary prevention. Primary prevention is literally preventing a negative health

event, such as an illness or injury, from occurring in the first place while secondary and tertiary prevention encompass minimizing the clinical impact and life long effects of a negative health event after it occurs. This is pertinent to today's hearing because, to date the vast majority of federally funded concussion research has focused on improving concussion diagnosis, improving concussion management, and improving our understanding of the long-term effects of concussion (e.g., CTE). While each are incredibly important endeavors, they are clearly associated with secondary or tertiary prevention, having very little to nothing to do with primary prevention. I believe we should be spending much more effort working to prevent our young athletes from being injured in the first place.

To that end, I was also quite pleased to learn that today's hearing would be focused on prevention efforts other than equipment. Simply stated, there is no such thing as a perfect piece of protective equipment – for example, no helmet will ever be able to prevent all concussions. Unfortunately aggressive marketing and our tendency to look for quick and easy fixes has led far too many parents to put far too much faith in the unsubstantiated concussion prevention claims of far too many manufacturers. While it is important to ensure the effectiveness of protective equipment is not oversold, it is even more important for us to realize that protective equipment will always only be only one piece of the concussion prevention puzzle. In public health we speak of the “three-legged stool of prevention” – the concept that the most effective prevention efforts are multi-faceted. The three legs of the prevention stool are engineering, education, and regulation. Our roadways are safer today despite the ever-increasing density of motor vehicle traffic because we have

effectively combined engineering (e.g., air bags, anti-lock breaks, etc.), education (drivers education classes, don't text and drive advertising campaigns, etc.), and regulation (speed limits, drunk driving laws, etc.). Effective sports-related concussion prevention efforts will likewise require a multi-faceted approach. While efforts to improve protective equipment is one "leg of the stool" this must be accompanied by educational efforts (e.g., the National Federation of High School Athletic Associations' [NFHS] recent recommendations regarding limiting the number of days a week football coaches incorporate full contact activities in practice sessions, the Center for Disease Control and Prevention's National Center for Injury Control and Prevention's "Heads Up" concussion toolkits for coaches, etc.) and regulatory efforts (e.g., Pop Warner's elimination of kick offs in their youngest age groups, better enforcement of the existing soccer rules to reduce player-player contact, etc.). These multi-faceted concussion prevention efforts must be evidence-based and sport specific – the stool is only stable if all three legs are strong.

However, in order to develop evidence-based, sport specific interventions we need better information. While evidence of the association between single or repeated blows to the head sustained during sports activity and brain injury was published in the medical literature as early as 1928, in its 2013 report on youth sports related concussions the Institute of Medicine noted that "The National Collegiate Athletic Association Injury Surveillance System and High School RIO™ (Reporting Information Online) data system are the only ongoing, comprehensive sources of sports-related injury data, including data on concussions, in young athletes." As the IOM report pointed out there is no national data collection tool

capturing equivalent sports injury information on athletes younger than high school age or high school aged children participating in sports outside of the school setting (e.g., recreational leagues, summer leagues, travel teams, all-star tournaments, summer camps, etc.). This literally means that no one is currently capable of providing reliable data on concussion incidence, rates, or patterns among the many millions of U.S. children younger than high school age or high school aged athletes playing outside the school setting. This is simply unacceptable because the importance of such information is undeniable and the knowledge, experienced personnel, and technical/methodological resources to obtain such information exists – the only thing which is lacking is adequate funding.

The NCAA and NFHS have provided a roadmap for all youth sports organizations. Those two institutions made the commitment to improve athlete health and safety by utilizing injury surveillance data in informed discussions leading to evidence-based decisions. I hope the work of this committee will somehow result in some source of federal support for an equivalent surveillance program for injuries sustained by our youngest athletes which could then be used by the numerous sports governing bodies overseeing youth sports. If federal funding is not a possibility, perhaps it is time to acknowledge that youth sports have become big business and to demand that national governing organizations utilize some of their profits to establish their own injury surveillance systems. Knowledge is power – in this case the knowledge gained from surveillance data can power efforts to keep young athletes safe and healthy.

Appendix 1: Peer-Reviewed Scientific Publications Reporting Data from The National High School Sports-Related Injury Surveillance Study (High School RIO™). Note: Concussion publications are bolded and student/trainee authors are italicized.

Of the 71 scientific papers reporting findings from analysis of the High School RIO™ dataset that have been published to date or currently in print, 17 (24%) have focused solely on concussions.

1. ***Bryan MA, Rowhani-Rahbar A, Comstock RD, and Rivara FP. Sports- and Recreation-Related Concussions in United States Youth. Forthcoming, Pediatrics.***
2. Johnson B and Comstock RD. Epidemiology of Chest, Rib, Thoracic Spine and Abdomen Injuries Among United States High School Athletes, 2005/05-2013/14. Forthcoming, *Clinical Journal of Sports Medicine*.
3. ***Currie DW, Comstock RD, Fields SK, and Cantu RC. A Paired Comparison of Initial and Recurrent Concussions Sustained by US High School Athletes within a Single Athletic Season. E-pub ahead of print, Journal of Head Trauma Rehabilitation. Published online May, 2016. DOI: 10.1097/HTR.0000000000000240.***
4. *Tirabassi J, Brou L, Khodae M, Lefort R, Fields SK, and Comstock RD. Epidemiology of High School Sports-Related Injuries Resulting in Medical Disqualification: 2005-2006 Through 2013-2014 Academic Years. E-pub ahead of print, American Journal of Sports Medicine. Published online May 10, 2016. DOI: 10.1177/0363546544604.*
5. ***Collins CL, McKenzie LB, Ferketich AK, Andridge R, Xiang H, and Comstock RD. Concussion Characteristics in High School Football by Helmet Age/Recondition Status, Manufacturer, and Model: 2008/09 Through 2012/13 Academic Years in the United States. E-pub ahead of print, American Journal of Sports Medicine. Published online Feb 23, 2016. PMID: 26905506.***
6. *Pierpoint LA, Williams CM, Fields SK, and Comstock RD. Epidemiology of Injuries in US High School Track and Field, 2008-2009 through 2013-2014. E-pub ahead of print, American Journal of Sports Medicine. Published online Feb 26, 2016. PMID: 26920435.*

7. Collins CL, McKenzie LB, Ferketich AK, Andridge R, Xiang H, and Comstock RD. Dental Injuries Sustained by High School Athletes in the United States, from 2008/09 through 2012/13 Academic Years. E-pub ahead of print, *Dental Traumatology*. Published online Sept 26, 2015. PMID: 26408377.
8. Ashack KA, Burton KA, Johnson TR, Currie DW, Comstock RD, and Dellavalle RP. Skin Infections Among US High School Athletes: A National Survey. E-pub ahead of print, *Journal of the American Academy of Dermatology*. Published online Feb 2, 2016. PMID: 26850656.
9. Mitchell J, Graham W, Best TM, Collins CL, Currie DW, Comstock RD, and Flanigan DC. Epidemiology of Meniscal Injuries in US High School Athletes Between 2007 and 2013. *Knee Surgery, Sports Traumatology, Arthroscopy*, 24(3):715-722 (2016).
10. Currie DW, Fields SK, Patterson MJ, and Comstock RD. Cheerleading Injuries in United States High Schools. *Pediatrics*, 137(1):1-9 (2016).
11. Dizdarevic I, Low S, Currie DW, Comstock RD, Hammoud S, and Atanda A. Epidemiology of Elbow Dislocation in High School Athletes. *American Journal of Sports Medicine*, 44(1):202-208 (2016).
12. Reeser JC, Gregory A, Berg RL, and Comstock RD. A Comparison of Women's Collegiate and Girls' High School Volleyball Injury Data Collected Prospectively Over a Four-Year Period. *Sport Health*, 7(6):504-510 (2015).
13. Kriz PK, Zurakowski RD, Almquist JL, Reynolds J, Ruggieri D, Collins CL, d'Hemecourt PA, and Comstock RD. Eye Protection and Risk Risk of Eye Injuries in High School Field Hockey. *Pediatrics*, 136(3):521-527 (2015).
14. **Comstock RD, Currie DW, Pierpoint LA, Grubenhoff JA, and Fields SK. An Evidence-Based Discussion of Heading and Concussions in High School Soccer. *JAMA Pediatrics*, 169(9):830-837 (2015).**
15. Roos KG, Marshall SW, Kerr ZY, Golightly YM, Kucera KL, Myers JB, Rosamond WD, and Comstock RD. Epidemiology of Overuse Injuries in College and High School Athletes in the United States. *American Journal of Sports Medicine*, 43(7):1790-1797 (2015).
16. Mitchell J, Magnussen RA, Collins CL, Currie DW, Best TM, Comstock RD, and Flanigan DC. Epidemiology of Patellofemoral Instability Injuries among High School Athletes in the United States. *American Journal of Sports Medicine*, 43(7):1676-1682 (2015).
17. Monfort SM, Comstock RD, Collins CL, Onate JA, Best TM, and Chaudhari AM. Association between Ball-Handling versus Defending Actions and Acute Noncontact Lower Extremity Injuries in High School Basketball and Soccer. *American Journal of Sports Medicine*, 43(4):802-807 (2015).
18. Matic GT, Sommerfeldt MF, Best TM, Collins CL, Comstock RD and Flanigan DC. Ice Hockey Injuries Among United States High School Athletes from

- 2008/2009-2012/2013. *The Physician and Sportsmedicine*, 43(2):119-125 (2015).
19. Schroeder AN, Comstock RD, Collins CL, Everhart J, Flanigan D, and Best TM. Epidemiology of Overuse Injuries Among High-School Athletes in the United States. *The Journal of Pediatrics*, 166(3): 600-606 (2015).
 20. Changstrom BG, Brou L, Khodae M, Braund C, and Comstock RD. Epidemiology of Stress Fracture Injuries Among U.S. High School Athletes, 2005-06 through 2012-13. *American Journal of Sports Medicine*, 43(1):26-33 (2015).
 21. **Kerr ZY, Collins CL, Mihalik JP, Marshall SW, Guskiewicz KM, and Comstock RD. Impact Locations and Concussion Outcomes in High School Football Player-to-Player Collisions. *Pediatrics*, 134(3):489-496 (2014).**
 22. **Collins CL, Fletcher EN, Fields SK, Kluchurosky L, Rohrkemper MK, Comstock RD, and Cantu RC. Neck Strength: A Protective Factor Reducing Risk for Concussion in High School Sports. *Journal of Primary Prevention*, 35(5):309-319 (2014).**
 23. Xiang J, Collins CL, Liu D, McKenzie LB, and Comstock RD. Lacrosse Injuries Among High School Boys and Girls in the United States, 2008-2012, Four Academic Years. *American Journal of Sports Medicine*, 42(9):2082-2088 (2014).
 24. Fletcher EN, McKenzie LB, and Comstock RD. Epidemiological Comparison of High School Basketball Injuries Reporting to Emergency Departments and the Athletic Training Setting. *Journal of Athletic Training*, 49(3):381-388 (2014).
 25. **Rosenthal JA, Foraker RE, Collins CL, and Comstock RD. National High School Athlete Concussion Rates From 2005-2006 to 2011-2012. *American Journal of Sports Medicine*, 42(7):1710-1715 (2014).**
 26. Robinson TW, Corlette J, Collins CL, and Comstock RD. Shoulder Injuries Among US High School Athletes, 2005/2006-2011/2012. *Pediatrics*, 133(2):272-279 (2014).
 27. Joseph AM, Collins CL, Henke NM, Yard EE, Fields SK, and Comstock RD. A Multisport Epidemiologic Comparison of Anterior Cruciate Ligament Injuries in High School Athletics. *Journal of Athletic Training*, 48(6):810-817 (2013).
 28. **Smith DW, Myer GD, Currie DW, Comstock RD, Clark JF, and Bailes JE. Altitude Modulates Concussion Incidence: Implications for Optimizing Brain Compliance to Prevent Injury in Athletes. *Orthopaedic Journal of Sports Medicine*, 1(6):1-7(2013).**
 29. Swenson DM, Collins CL, Fields SK, and Comstock RD. Epidemiology of US High School Sports-Related Ligamentous Ankle Injuries 2005/06-2010/11. *Clinical Journal of Sports Medicine*, 23(3):190-196 (2013).

30. Swenson DM, Collins CL, Best TM, Flanigan DC, Fields SK, and Comstock RD. Epidemiology of Knee Injuries Among US High School Athletes, 2005/06-2010/11. *Medicine & Science in Sports & Exercise*, 45(3):462-469 (2013).
31. Badgeley MA, McIlvain NM, Yard E, Fields S, and Comstock RD. Epidemiology of 10,000 High School Football Injuries: Patterns of Injury by Position Played. *Journal of Physical Activity & Health*, 10(2);160-169 (2013).
32. **Chrisman SP, Rivara FP, Schiff MA, Zhou C, and Comstock RD. Risk Factors for Concussive Symptoms of 1 Week or Longer in High School Athletes. *Brain Injury*, 27(1);1-9 (2013).**
33. Kerr ZY, Casa DJ, Marshall SW, and Comstock RD. Epidemiology of Exertional Heat Illness Among U.S. High School Athletes. *American Journal of Preventive Medicine*, 44(1);8-14 (2013).
34. Kriz PK, Comstock RD, Zurakowski RD, Almquist JL, Collins CL and D'Hemecourt P. Effectiveness of Protective Eyewear in Reducing Eye Injuries Among High School Field Hockey Players. *Pediatrics*, 130(6);1069-1075 (2012).
35. Swenson DM, Henke NM, Collins CL, Fields SK, and Comstock RD. Epidemiology of United States High School Sports-Related Fractures, 2008-09 to 2010-11. *American Journal of Sports Medicine*, 40(9);2078-2084 (2012).
36. **Castile L, Collins CL, McIlvain NM, and Comstock RD. The Epidemiology of New vs. Recurrent Sports Concussions Among High School Athletes, 2005-2010. *British Journal of Sports Medicine*, 46(8);603-610 (2012).**
37. **Marar M, McIlvain NM, Fields SK, and Comstock RD. Epidemiology of Concussions among United States High School Athletes in 20 Sports. *American Journal of Sports Medicine*, 40(4);747-755 (2012).**
38. **Meehan WP, d'Hemecourt P, Collins CL, Taylor AM, and Comstock RD. Computerized Neurocognitive Testing for the Management of Sport-Related Concussions. *Pediatrics*, 129(1);1-7 (2012).**
39. **Meehan WP, d'Hemecourt P, Collins CL, and Comstock RD. Assessment and Management of Sport-Related Concussions in United States High Schools. *American Journal of Sports Medicine*, 39(11);2304-2310 (2011).**
40. Rechel JA, Collins CL, and Comstock RD. Epidemiology of Injuries Requiring Surgery among High School Athletes in the United States, 2005 to 2010. *Journal of Trauma*, 71(4);982-989 (2011).
41. Kerr ZY, Collins CL, Fields SK, and Comstock RD. Epidemiology of Player-Player Contact Injuries among US High School Athletes, 2005-2009. *Clinical Pediatrics*, 50(7);594-603 (2011).
42. Kerr ZY, Collins CL, Pommering TL, Fields SK, and Comstock RD. Dislocation/Separation Injuries among US High School Athletes in 9 Selected Sports: 2005-2009. *Clinical Journal of Sports Medicine*, 21(2); 101-108 (2011).

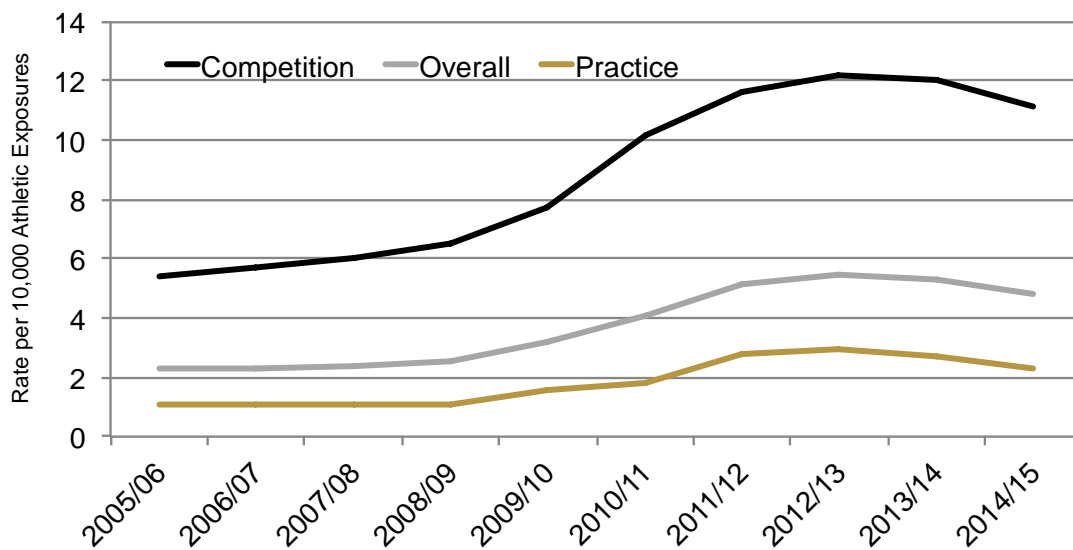
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45. Gilchrist J, Haileyesus T, Murphy M, Comstock RD, Collins C, McIlvain N, and Yard E. Heat Illness Among High School Athletes – United States, 2005-2009. *JAMA* 305(3);246-249 (2011) – (JAMA reprint of *MMWR*)
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47. **Meehan WP, d’Hemecourt P, and Comstock RD. High School Concussions in the 2008-2009 Academic Year: Mechanism, Symptoms, and Management. *American Journal of Sports Medicine*, 38(12);2405-2409 (2010).**
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49. Swenson DM, Yard EE, Collins CL, Fields SK, and Comstock RD. Epidemiology of US High School Sports-Related Fractures, 2005-2009. *Clinical Journal of Sports Medicine* 20(4);293-299 (2010).
50. Krajnik S, Fogarty KJ, Yard EE, and Comstock RD. Shoulder Injuries in US High School Baseball and Softball Athletes, 2005-2008. *Pediatrics* 125(3);497-501 (2010).
51. Yard EE, Collins CL, and Comstock RD. A Comparison of High School Sports Injury Surveillance Data Reporting by Certified Athletic Trainers and Coaches. *Journal of Athletic Training* 44(6);645-652 (2009).
52. Darrow CJ, Collins CL, Yard EE, and Comstock RD. Epidemiology of Severe Injuries among United States High School Athletes: 2005-2007. *American Journal of Sports Medicine* 37(9);1798-1805 (2009).
53. **Yard EE and Comstock RD. Compliance with Return to Play Guidelines Following Concussion in US High School Athletes, 2005-2008. *Brain Injury* 23(11);888-898 (2009).**
54. Swenson DM, Yard EE, Fields SK, and Comstock RD. Patterns of Recurrent Injuries among US High School Athletes, 2005-2008. *American Journal of Sports Medicine* 37(8);1586-1593 (2009).
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56. *Bonza J, Fields SK, Yard EE, and Comstock RD. Shoulder Injuries Among United States High School Athletes, 2005-2007. Journal of Athletic Training 44(1);76-83 (2009).*
57. *Huffman EA, Yard EE, Fields SK, Collins CL, and Comstock RD. Epidemiology of Rare Injuries and Conditions among US High School Athletes during the 2005-06 and 2006-07 School Years. Journal of Athletic Training 43(6);624-630 (2008).*
58. *Borowski L, Yard EE, Fields SK, and Comstock RD. The Epidemiology of US High School Basketball Injuries, 2005-2007. American Journal of Sports Medicine 36(12);2328-2335 (2008).*
59. *Yard EE, Schroeder MJ, Fields SK, Collins CL, and Comstock RD. The Epidemiology of US High School Soccer Injuries, 2005-2007. American Journal of Sports Medicine 36(10);1930-1937 (2008).*
60. *Collins CL and Comstock RD. Epidemiologic Features of High School Baseball Injuries in the United States, 2005-2007. Pediatrics 121(6);1181-1187 (2008).*
61. *Ingram JG, Yard EE, Fields SK, and Comstock RD. Epidemiology of Knee Injuries among Boys and Girls in US High School Athletics. American Journal of Sports Medicine 36(6);1116-1122 (2008).*
62. *Rechel JA, Yard EE, and Comstock RD. An Epidemiologic Comparison of High School Sports Injuries Sustained in Practice and Competition. Journal of Athletic Training 43(2);197-204 (2008).*
63. *Collins CL, Fields SK, and Comstock RD. When the Rules of the Game are Broken: What Proportion of High School Sports-Related Injuries are Related to Illegal Activity? Injury Prevention 14(1);34-38 (2008).*
64. *Yard EE, Collins CL, Dick RW, and Comstock RD. An Epidemiologic Comparison of High School and College Wrestling Injuries. American Journal of Sports Medicine 36(1);57-64 (2008).*
65. ***Gessel LM, Fields SK, Collins CL, Dick RW, and Comstock RD. Concussions Among High School and College Athletes. Journal of Athletic Training 42(4);495-503 (2007).***
66. *Nelson AJ, Collins CL, Yard EE, Fields SK, and Comstock RD. The Epidemiology of Ankle Injuries Among US High School Athletes, 2005-06. Journal of Athletic Training 42(3);381-387 (2007).*
67. *Shankar PR, Fields SK, Collins CL, Dick RW, and Comstock RD. Epidemiology of High School and Collegiate Football Injuries in the United States, 2005-2006. American Journal of Sports Medicine 35(8);1295-1303 (2007).*
68. *Fernandez WG, Yard EE, and Comstock RD. Epidemiology of Lower Extremity Injuries Among US High School Athletes. Academic Emergency Medicine 14(7);641-645 (2007).*

69. Comstock RD, Knox C, and Gilchrist J. Sports-Related Injuries Among High School Athletes United States, 2005-06 School Year. *Connecticut Medicine* 71(1);19-21 (2007).
70. Comstock RD, Knox C, *Yard E*, and Gilchrist J. Sports-Related Injuries Among High School Athletes – United States, 2005-06 School Year. *JAMA* 296(22);2673-2674 (2006) – (*JAMA* reprint of *MMWR*).
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Appendix 2: Concussion Rates Over Time Among Athletes Participating in the Nine Popular U.S. High School Sports (Football, Boys' and Girls' Soccer, Girls' Volleyball, Wrestling, Boys' and Girls' Basketball, Baseball, and Softball) Which Have Been Under Continuous Surveillance Over the Past Decade, High School RIO™ Study, 2005/06 through 2014/15

Concussion Rates per 10,000 AE



Appendix 3: Concussion Rates Among U.S. High School Athletes Vary by Sport and Type of Athletic Activity, High School RIO™ Study, 2014/15

Concussion Rates per 10,000 AEs: 2014/15

Sport	Competition	Rank	Practice	Rank
Football	30.5	1	5.0	1
Girls' Soccer	20.7	2	2.1	3
Boys' Ice Hockey	15.9	3	1.2	9
Boys' Lacrosse	11.3	4	1.0	11
Girls' Basketball	9.9	5	1.7	6
Boys' Wrestling	9.1	6	2.1	4
Boys' Soccer	8.9	7	0.9	12
Girls' Lacrosse	7.7	8	1.3	8
Field Hockey	7.1	9	0.9	13
Girls' Volleyball	4.9	10	1.9	5
Boys' Basketball	3.4	11	1.1	10
Softball	3.0	12	1.5	7
Baseball	2.4	13	0.5	14
Cheerleading*	1.8	14	2.6	2

Colorado School of **Public Health** *Competition includes competition and performance

AE = Athletic Exposure with one athlete participating in one practice or competition representing one athletic exposure.

Appendix 4: Improvement in U.S. High School Athletes' Compliance with Return to Play Guidelines Over Time, High School RIO™ Study, 2005/06 through 2014/15

Trends in Return to Play Time (RTP)

% of HS Student Athletes in Each Category of RTP by Year

	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15
<1 day	7.9	2.6	1.5	0.8	1.8	0.6	0.9	1.7
1-2 days	6.7	6.4	4.0	2.4	1.9	0.8	1.0	0.9
3-6 days	21.4	19.5	17.9	12.9	9.0	8.3	7.6	7.0
Season DQ	2.8	3.6	4.6	4.1	4.4	3.0	2.6	2.4
Career DQ	0.2	0.1	0.3	0.3	0.2	0.4	0.4	0.4
Season ended	0.8	0.1	8.7	12.2	14.2	14.5	14.0	15.8
Athlete quit sports despite no DQ	0.4	1.4	1.2	1.4	1.9	1.9	2.7	1.9

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Note: column %'s do not sum to 100% because not all return to play categories captured by High School RIO™ are displayed in this table. Rather, only those categories indicating a failure to comply with return to play guidelines (i.e., <1 day, 1-2 days, and 3-6 days) or indicating concussions of particular concern or interest (i.e., all others included in this table) are presented.