ACTIVE & SAFE

Evidence Summary: Football

Liraz Fridman, PhD

Version 1
February 2018

BC INJURY research and prevention unit

The British Columbia Injury Research and Prevention Unit (BCIRPU) was established by the Ministry of Health and the Minister's Injury Prevention Advisory Committee in August 1997. BCIRPU is housed within the Evidence to Innovation research theme at BC Children's Hospital (BCCH) and supported by the Provincial Health Services Authority (PHSA) and the University of British Columbia (UBC). BCIRPU's vision is *to be a leader in the production and transfer of injury prevention knowledge and the integration of evidence-based injury prevention practices into the daily lives of those at risk, those who care for them, and those with a mandate for public health and safety in British Columbia.*

Author: Liraz Fridman

Editors: Sarah A Richmond, Amanda Black

For any questions regarding this report, contact:

BC Injury Research and Prevention Unit
F508 – 4480 Oak Street
Vancouver, BC V6H 3V4
Email: bcinjury1@cw.bc.ca
Phone: (604) 875-3776
Fax: (604) 875-3569
Website: www.injuryresearch.bc.ca

Suggested Citation:

Fridman L, Richmond SA, Black A, Pike I, Babul S. *Evidence Summary: Football.* Active & Safe Central. BC Injury Research and Prevention Unit: Vancouver, BC; 2018. Available at http://activesafe.ca/.

UBC BC Children's Hospital Research Institute

Evidence synthesis tool

SPORT:	Football	**Target Group:**	Youth, High-School, & Collegiate Male Football Players	
Injury Mechanisms:	Injury Types: Concussions, Shoulder Injuries (AC), Knee Injuries, hamstring injuries, heat injuries, overuse injuries Mechanisms: Player-to-player contact (tackling); games vs. practices; playing surface; player position; protective equipment			
Incidence/Prevalence	**Risk/Protective Factors**	**Interventions**	**Implementation/Evaluation**	**Resources**
Youth Athletes Injury rate for high-school athletes is reported as 4.08 per 1000 Athletic Exposures (A-Es) between the 2005-2010 academic years.[1] High-school football related concussion incidence rates ranged from 0.48 – 1.03 per 1000 A-Es.[2] One study assessing concussions rates in 2012 and 2013 seasons reported that 11.8% and 66.4% of all concussions were sustained by youth and high school football athletes respectively.[3] **Collegiate Athletes** Between 2004-2009 academic years, 18,075 football injuries were reported in collegiate athletes. The highest injury rates were found in competitions (36.94/1000 A-Es), occurring in the lower	**Playing Surface** Systematic reviews have demonstrated strong evidence for differences in injury rates between artificial turf and natural turf/grass.[1] Studies have reported higher injury rates for NFL players who participated in games on turf vs. grass (IDR=1.22, 95% CI,1.09-1.36).[2] In one study, the risk of sustaining a shoulder injury was significantly higher on grass than synthetic surfaces (IRR= 1.36, 95% CI, 1.02-1.81).[3] It is reported that the odds of sustaining an injury are higher when there are higher levels of rotational traction at the shoe-surface interface (OR=2.73, 95% CI, 2.13-3.15.[4] **Position** Offensive players report a significantly higher number of concussions, compared to other positions in football.[5-6] One systematic review reported that offensive quarterbacks had the	There is a lack of literature on interventions to reduce the risk injury in football. A pre-season health acclimatization guideline was shown to be effective in reducing exertional heat injuries (EHIs) in football players.[1] One study examined a comprehensive coach education program (Heads-Up Football - HUF) and practice contact restriction guidelines (Pop Warner - PW) on injury rates. Compared with football players who were in the non-Heads Up Football (NHUF) group, practice injury rates were lower for HUF and PW groups [0.97/1000 A-Es, IRR=0.13, 95% CI, 0.08-0.21; 2.73/1000 A-Es, IRR=0.37, 95% CI, 0.26-0.53].[2] One study evaluated the NCAA concussion management policies on concussion rates.[3] This study found that the combined incidence rate of concussions doubled from the previous season, post-implementation of new	In one study examining the effectiveness of guidelines to reduce EHI in football players, compliance to the implemented guidelines was low.[1] The study that evaluated the NCAA concussion management policies on concussion rates and found that concussions increased, post implementation of new NCAA policies on concussion management hypothesized that the increase was likely due to an increase in reporting of concussions.[2] **Barriers/Facilitators to Implementation** Future studies need to elucidate what facilitators lead to compliance of heat acclimatization guidelines.[1] One study reported the following facilitators to the implementation of concussion education laws in the United States:[3] 1. Prior state-level activity on concussion awareness and management, building upon existing requirements.	**Websites** Stop Sports Injuries: http://www.stopsportsinjuries.org/STOP/Prevent_Injuries/Football_Skating_Injury_Prevention.aspx National Collegiate Athletic Association: https://www.ncaa.org/sites/default/files/NCAA_Football_Injury_WEB.pdf

extremity (56%) and consisted of strains/sprains (50.6%).[4] College football related concussion incidence rates are reported to range from 0.52– 0.81 per 1000 A-Es.[2] **National Football League (NFL) Players** Rate of acromioclavicular joint (AC) injuries was 26.1 per 10,000 A-Es and the majority of these injuries occurred on natural grass during passing plays.[5] In 480 games, there were 292 concussion resulting in 0.61 concussions per game (95% CI, 0.54-0.68), 6.61 concussions per 1000 A-Es (95% CI, 5.85-7.37).[6] There is a high incidence rate for serious injuries, including concussions, in male football players.[2,7] The mechanism of injury has been attributed to high speed player-to-player contact/tackling.[1-2, 8-11] Football practices are reported to be a major source of concussion at all levels of play.[3, 9] There is a high incidence rate of hamstring strains reported by football players in	highest risk of sustaining a concussion compared with all other playing positions (1.7 to 5 fold increase) [range of IRR=1.72 (95% CI, 1.14-2.60) to 5.59, (95% CI, 3.90 to 8.02)].[5] **Weather** Colder game-day temperatures are associated with an increase risk of concussion (IRR = 2.16, 95% CI, 1.35-3.45) and ankle injuries.[3] The odds of sustaining a concussion are reported to be 30% lower for NFL athletes who play at higher elevations (OR=0.70, 95% CI, 0.53-0.94).[7] **Protective Equipment** One study that looked at lace-up ankle braces found that players who used this equipment had lower incidence rates of ankle injuries but no differences were seen for other lower extremity injuries (HR=0.39, 95% CI, 0.24-0.65).[8] McGuine et al., found no difference in the incidence of concussions for players wearing different brands of helmets. However, custom mouth guards were associated with a higher rate of sports-related concussions compared to those who wore a generic mouth guard (HR=1.69, 95% CI, 1.20-2.37).[9]	NCAA policies on concussion management.[3] Findings support comprehensive coach education and practice contact restrictions as effective injury prevention and intervention strategies.[2]	2. Pre-existence of training requirements. 3. Vesting authority for implementation with central organizing bodies that have prior familiarity with target populations and protocols. 4. Key partnerships during both legislative and implementation processes. 5. Smoother path to implementation if agencies responsible were involved in legislative process.	

practice.[9] This may be due to explosive or decelerating movements without adequate rest.[12] Lower extremity injury rates remain high and have increased in NCAA football athletes over time.[4, 10-11] The highest average annual rate of ACL injuries was found in men's football, compared to other sports.[13] Some studies report that incidence rates for injuries and concussions are higher in games[14-16] compared to practice; others report higher rates in practices.[4, 7, 10-11] One factor for consideration in these analyses, is level of play.				
Works Cited: 1. Badgeley, M.A., McIlvain, N.M., Yard, E.E., Fields, S.K., & Comstock, R.D. (2013). Epidemiology of 10,000 high school football injuries: Patterns of injury by position played. Journal of Physical Activity and Health, 10, 160-169. 2. Clay, M.B., Glover, K.T., & Lowe, D.T. (2013). Epidemiology of concussion in sport: a literature review. *Journal of Chiropractic*	**Works Cited:** 1. Williams, S., Hume, P.A., & Kara, S. (2011). A review of football injuries on third and fourth generation artificial turfs compared with natural turf. *Sports Medicine, 41(11)*, 903-923. 2. Hershman, E.B., Anderson, R., Bergfeld, J.A., Bradley, J.P., Coughlin, M.J., Johnson, R.J., …, & Powell, J.W. (2012). An analysis of specific lower extremity injury rates on grass and field turf playing surfaces in National Football League games: 2000-2009 seasons.	**Works Cited:** 1. Barron, M.J., Branta, C.F., Powell, J.W., Ewing, M.E., Gould, D.R., & Maier, K. (2014). Effects of an injury prevention program on injury rates in American youth football. *International Journal of Sports Science & Coaching, 9(5)*, 1227 – 1240. 2. Kerr, Z.Y., Yeargin, S., Valovich McLeod, T.C., Nittoli, V.C., Mensch, J., Dodge, T.,…, & Dompier, T.P. (2015). Comprehensive coach education and practice contact restriction	**Works Cited:** 1. Barron, M.J., Branta, C.F., Powell, J.W., Ewing, M.E., Gould, D.R., & Maier, K. (2014). Effects of an injury prevention program on injury rates in American youth football. *International Journal of Sports Science & Coaching, 9(5)*, 1227 – 1240. 2. Kilcoyne, K.G., Dickens, J.F., Svoboda, S.J., Owens, B.D., Cameron, K.L., Sullivan, R.T., & Rue, J.P. (2014). Reported concussion rates for three Division I football programs: An evaluation of the new NCAA concussion policy. *Sports Health, 6(5)*,	

Medicine, 12, 230-251. 3. Dompier, T.P., Kerr, Z.Y., Marshall, S.W., Hainline, B., Snook, E.M., Hayden, R., & Simon, J.E. (2015). Incidence of concussion during practice and games in youth, high school, and collegiate American football players. *JAMA Pediatrics, 169(7)*, 659-665. 4. Kerr, Z.Y., Simon, J.E., Grooms, D.R., Roos, K.G., Cohen, R.P., & Dompier, T.P. (2016). Epidemiology of Football Injuries in the National Collegiate Athletic Association, 2004-2005 to 2008-2009. *The Orthopaedic Journal of Sports Medicine, 3(7),* 1-8. 5. Lynch, T.S., Saltzman, M.D., Ghodasra, J.H., Bilimoria, K.Y., Bowen, M.K., & Nuber, G.W. (2013). Acromioclavicular joint injuries in the National Football League. American Journal of Sports Medicine, 41(12), 2904-2908. 6. Nathanson, J.T., Connolly, J.G., Yuk, F., Gometz, A., Rasouli, J., Lovell, M., & Choudhri, T. (2016). Concussion incidence in	*American Journal of Sports Medicine, 40(10)*, 2200 – 2205. 3. Lawrence, D.W., Comper, P., Hutchison, M.G. (2016). Influence of extrinsic risk factors on National Football League injury rates. *Orthopaedic Journal of Sports Medicine, 4(3)*, 1-9. 4. Thomson, A., Whiteley, R., & Bleakley, C. (2015). Higher shoe-surface interaction is associated with doubling of lower extremity injury risk in football codes: a systematic review and meta-analysis. *Br J Sports Med, 49,* 1245-1252. 5. Abrahams, S., McFie, S., Patricios, J., Posthumus, M., & September, A.V. (2014). Risk factors for sports concussion: an evidence-based systematic review. *Br J Sports Med, 48,* 91-97. 6. Teramoto, M., Petron, D.J., Cross, C.L., & Willick, S.E. (2015). Style of play and rate of concussions in the National Football League. *The Orthopaedic Journal of Sports Medicine, 3(12)*, 1-9. 7. Myer, G.D., Smith, D., Barber Foss, K.D., Dicesare, C.A., Kiefer, A.W., Kushner, A.M., Thomas, S.M., …, & Khoury, J.C. (2014). Rates of	guidelines result in lower injury rates in youth American football. *The Orthopaedic Journal of Sports Medicine, 3(7)*, 1-8. 3. Kilcoyne, K.G., Dickens, J.F., Svoboda, S.J., Owens, B.D., Cameron, K.L., Sullivan, R.T., & Rue, J.P. (2014). Reported concussion rates for three Division I football programs: An evaluation of the new NCAA concussion policy. *Sports Health, 6(5)*, 402-405.	402-405. 3. McGowan Lowrey, K. & Morain, S.R. (2014). State experiences implementing youth sports concussion laws: Challenges, successes, and lessons for evaluating impact. *Journal of Law, Medicine, & Ethics,* 290-296.	

professional football: position-specific analysis with use of a novel metric. *Orthopaedic Journal of Sports Medicine, 4(1)*, 1-6. 7. Zuckerman, S.L., Kerr, Z.Y., Yengo-Kahn, A., Wasserman, E., Covassin, T., & Solomon, G.S. (2015). Epidemiology of sports-related concussion in NCAA athletes from 2009-2010 to 2013-2014 – incidence, recurrence, and mechanisms. *American Journal of Sports Medicine, 43(11)*, 2654-2662. 8. Kerr, Z.Y., Hayden, R., Dompier, T.P., & Cohen, R. (2015). Association of equipment worn and concussion injury rates in National Collegiate Athletic Association football practices. *American Journal of Sports Medicine, 43(5)*, 1134-1141. 9. Kontos, A.P., Elbin, R.J., Fazio-Sumrock, V.C., Burkhart, S., Swindell, H., Maroon, J., & Collins, M.W. (2013). Incidence of sports-related concussions among youth football players aged 8-12 years. *Journal of Pediatrics, 163(3),* 717-720.	concussion are lower in National Football League games played at higher altitudes. *Journal of Orthopaedic & Sports Physical Therapy, 44(3)*, 164-172. 8. McGuine, T.A., Hetzel, S., Wilson, J., & Brooks, A. (2012). The effect of lace-up ankle braces on injury rates in high school football players. American Journal of Sports Medicine, 40(1), 49-57. 9. McGuine, T.A., Hetzel, S., McCrea, M., & Brooks, M.A. (2014). Protective equipment and player characteristics associated with the incidence of sport-related concussion in high school football players: A multifactorial prospective study. *American Journal of Sports Medicine, 42(10)*, 2470-2478.			

10. Westermann, R.W., Kerr, Z.Y., Wehr, P., & Amendola, A. (2016). Increasing lower extremity injury rates across the 2009-2010 to 2014-2015 seasons of National Collegiate Athletic Association football – an unintended consequence of the "Targeting" rule used to prevent concussions? *American Journal of Sports Medicine, 44(12),* 3230-3236. 11. McGuine, T.A., Hetzel, S., McCrea, M., & Brooks, M.A. (2014). Protective equipment and player characteristics associated with the incidence of sport-related concussion in high school football players: A multifactorial prospective study. *American Journal of Sports Medicine, 42(10)*, 2470-2478. 12. Dalton, S.L., Kerr, Z.Y., & Dompier, T.P. (2015). Epidemiology of hamstring strains in 25 NCAA sports in the 2009-2010 to 2013-2014 academic years. *American Journal of Sports Medicine, 43(11),* 2671-2679. 13. Agel, J., Rockwood, T., & Klossner, D. (2016). Collegiate ACL injury rates across 15 sports: National Collegiate				

Athletic Association injury surveillance system data update (2004-2005 through 2012-2013). *Clinical Journal of Sports Medicine, 26(6)*, 18-523. 14. Caswell, S.V., Ausborn, A., Diao, G., Johnson, D.C., Johnson, T.S., Atkins, R., Ambegaonkar, J.P., & Cortes, N. (2016). Anthropometrics, physical performance, and injury characteristics of youth American football. Orthopaedic Journal of Sports Medicine, 4(8), 1-8. 15. Houck, Z., Asken, B., Bauer, R., Pothast, J., Michaudet, C., & Clugston, J. (2016). Epidemiology of Syndesmosis Injuries in intercollegiate football: incidence and risk factors from National Collegiate Athletic Association injury surveillance system data from 2004-2005 to 2008-2009. *American Journal of Sports Medicine, 44(9),* 2269 – 2275. 16. Iguchi, J., Yamada, Y., Kimura, M., Fujisawa, Y., Hojo, T., Kuzuhara, K., & Ichihasha, N. (2013). Injuries in a Japanese Division I collegiate American football				

team: A 3-season prospective study. *Journal of Athletic Training, 48(6),* 818-825.				

Review of Sport Injury Burden, Risk Factors and Prevention

Football

Incidence and Prevalence

Youth Athletes

Injury rates vary for high school football players by position. Between the 2005-2010 academic years, the injury rate for high-school athletes who played football was 4.08 per 1000 athletic exposures (A-Es). (Badgeley et al., 2013) Offensive linemen sustained the majority of injures (18.3% of all injuries) and the most common body parts injured were the knee (15.4%), ankle (13.3%), and head/face (12.9%). (Badgeley et al., 2013) In a study that examined concussions in youth athletes, high-school football related concussion incidence rates ranged from 0.48 – 1.03 per 1000 A-Es. (Clay et al., 2013) One study that assessed concussions rates in the 2012 and 2013 seasons reported that 11.8% and 66.4% of all concussions were sustained by youth and high school football athletes, respectively. (Dompier et al., 2015)

Collegiate Athletes

Between the 2004-2009 academic years, 18,075 football injuries were reported in NCAA athletes. The highest injury rate was found in competitions (36.94/1000 A-Es), and the majority of injuries occurred in the lower extremity (56%) and consisted of strains/sprains (50.6%). (Kerr et al., 2016) In a systematic review by Clay et al., (2013) college football related concussion incidence rates ranged from 0.52– 0.81 per 1000 A-Es.

National Football League (NFL) Players

Shoulder injuries, particularly acromioclavicular joint (AC) injuries occur frequently in the NFL. The rate of AC injuries was 26.1 per 10,000 A-Es and the majority of these occurred on natural grass during passing plays. (Lynch et al., 2013) In another study that assessed head injuries among NFL players, in 480 games, there were 292 concussion resulting in 0.61 concussions per game (95% CI, 0.54-0.68), 6.61 concussions per 1000 A-Es (95% CI, 5.85-7.37). (Nathanson et al., 2016)

Mechanism/Type of Injury/Body Part Injured

The most common mechanism of injury in football is reported to be high speed player-to-player contact/tackling. (Badgeley et al., 2013; Clay et al., 2013; Kerr et al., 2015; Kontos et al., 2013; McGuine et al., 2014; Westermann et al., 2016) It is reported that concussions are a common injury occurring in football practices, (Dompier et al., 2015; Kontos et al., 2013), in addition to high rates of hamstring strains. (Kontos et al., 2013) This may be due to the explosive or decelerating movements in football. (Dalton et al., 2015) Lower extremity injury rates are high and are reported to have increased in NCAA football athletes over time. (Kerr et al., 2016;

McGuine et al., 2014; Westermann et al., 2016) In comparison to other sports, the highest average annual rate of ACL injuries was found in men's football. (Agel et al., 2016)
Some studies report that incidence rates for injuries and concussions are higher in games (Caswell et al., 2016; Houck et al., 2016; Iguchi et al., 2013) compared to practice, while others report higher rates in practice. (Kerr et al., 2016; McGuine et al., 2014; Westermann et al., 2016; Zuckerman et al., 2015) One factor for consideration in these analyses, is level of play.

Limitations

The studies reviewed varied in how they measured exposure data in the calculation of injury rates (100 vs. 1000 vs. 10, 000 A-Es, games vs. practices, level of play, etc.). The variability in data collection and analyses results in the inability to compared studies.

Risk and Protective Factors

Playing Surface

Systematic reviews demonstrate strong evidence for differences in injury rates between artificial turf and natural turf/grass. (Williams et al., 2011) Studies report higher injury rates for NFL players who participate in games on turf vs. grass. (Hershmann et al., 2012) In one study, the risk of sustaining a shoulder injury was significantly higher on grass, compared to synthetic surfaces. (Lawrence et al., 2016) The odds of sustaining an injury are higher when there are higher levels of rotational traction at the shoe-surface interface. (Thomson et al., 2015)

Position

Offensive players report a significantly higher number of concussions generally (Abrahams et al., 2014; Teramoto, 2015). One systematic review reported that offensive quarterbacks had the highest risk of sustaining a concussion compared with all other playing positions (1.7 to 5 fold increase) (Abrahams et al., 2014).

Weather

Weather is another factor that contributes to injury incidence. Colder game-day temperature was associated with an increased risk of concussion and ankle injuries. (Lawrence et al., 2016) In addition, it is reported that the odds of sustaining a concussion were 30% lower for NFL athletes who played at higher elevations. (Myer et al., 2014)

Protective Equipment

Protective equipment such as lace-up ankle braces has shown to lower the incidence of ankle injury; however, no differences were seen when examining other lower extremity injuries. (McGuine et al., 2012) The use of other protective equipment such as helmets and mouth guards has also been examined. McGuine et al. (2014) found no difference in the incidence of concussions for players wearing different brands of helmets; however, custom mouth guards

were associated with a higher rate of sports-related concussions compared to those who wore a generic mouth guard.

Opportunities for Prevention: Effective Interventions, Cost-Effectiveness, Implementation and Evaluation

There is an overall lack of literature on interventions to reduce the risk injury in football. One study examined a pre-season health acclimatization guideline and demonstrated a reduction in exertional heat injuries (EHIs) in football players. (Barron et al., 2014) Another study examined a comprehensive coach education (Heads-Up Football - HUF) and practice contact restriction guidelines (Pop Warner - PW) on injury rates. Compared with football players who were in the non-Heads Up Football (NHUF) group, practice injury rates were lower for HUF and PW groups. (Kerr et al., 2015) These findings support comprehensive coach education and practice contact restrictions as effective injury prevention and intervention strategies. (Kerr et al., 2015)

A pilot study demonstrated an 85% reduction in concussion risk by providing vision training to collegiate football players in pre-season; however, further studies are needed to further evaluate this recommendation. (Clark et al. 2015) A study by Kilcoyne et al., (2014) evaluated the NCAA concussion management policy change on concussion rates. This study found that the combined incidence rate of concussions doubled from the previous season, post-implementation of new NCAA policies on concussion management.

Finally, a recent systematic review identified the importance of helmet fit in youth football to potentially reduce the severity of concussion symptoms. While, cohort level evidence supports this recommendation, more rigorous study designs are needed (Emery et al., 2017).

Cost Effectiveness

No studies examined the cost-effectiveness of implementing interventions to prevent injuries in football players.

Implementation/Evaluation

Heat acclimatization guidelines and concussion management policies are two strategies that have been implemented to prevent injuries among football players. Compliance with pre-season health acclimatization guidelines has shown to be effective in reducing exertional heat injuries (EHIs) in football players; however, a low proportion of high school football players complied with all the recommended guidelines. (Barron et al., 2014) NCAA concussion management policies have been previously evaluated and authors found that the combined incidence rate of concussions doubled from previous season after the implementation of new NCAA policies on concussion management. (Kilcoyne et al., 2014) The authors hypothesized that the increase was likely due to an increase in reporting of concussions.

Limitations

There are few studies that have evaluated the effectiveness of interventions such as comprehensive education programs and contact restrictions to reduce injury in football. Future studies need to elucidate what facilitators lead to compliance of heat acclimatization guidelines and the most effective way to implement these prevention strategies. (Barron et al., 2014)

References

Abrahams, S., McFie, S., Patricios, J., Posthumus, M., & September, A.V. (2014). Risk factors for sports concussion: an evidence-based systematic review. *British Journal of Sports Medicine, 48,* 91-97. doi: 10.1136/bjsports-2013-092734.

Agel, J., Rockwood, T., & Klossner, D. (2016). Collegiate ACL injury rates across 15 sports: National Collegiate Athletic Association injury surveillance system data update (2004-2005 through 2012-2013). *Clinical Journal of Sports Medicine, 26(6)*, 18-523.

Badgeley, M.A., McIlvain, N.M., Yard, E.E., Fields, S.K., & Comstock, R.D. (2013). Epidemiology of 10,000 high school football injuries: Patterns of injury by position played. *Journal of Physical Activity and Health, 10,* 160-169.

Barron, M.J., Branta, C.F., Powell, J.W., Ewing, M.E., Gould, D.R., & Maier, K. (2014). Effects of an injury prevention program on injury rates in American youth football. *International Journal of Sports Science & Coaching, 9(5)*, 1227 – 1240.

Caswell, S.V., Ausborn, A., Diao, G., Johnson, D.C., Johnson, T.S., Atkins, R., Ambegaonkar, J.P., & Cortes, N. (2016). Anthropometrics, physical performance, and injury characteristics of youth American football. *Orthopaedic Journal of Sports Medicine, 4(8),* 1-8. doi: 10.1177/2325967116662251.

Clark JF, Graman P, Ellis JK, *et al*. (2015). An exploratory study of the potential effects of vision training on concussion incidence in football. *Optometry and Visual Performance*,3;.

Clay, M.B., Glover, K.T., & Lowe, D.T. (2013). Epidemiology of concussion in sport: A literature review. *Journal of Chiropractic Medicine, 12,* 230-251. doi: 10.1016/j.jcm.2012.11.005

Dalton, S.L., Kerr, Z.Y., & Dompier, T.P. (2015). Epidemiology of hamstring strains in 25 NCAA sports in the 2009-2010 to 2013-2014 academic years. *American Journal of Sports Medicine, 43(11),* 2671-2679. doi: 10.1177/0363546515599631

Dompier, T.P., Kerr, Z.Y., Marshall, S.W., Hainline, B., Snook, E.M., Hayden, R., & Simon, J.E. (2015). Incidence of concussion during practice and games in youth, high school, and collegiate American football players. *JAMA Pediatrics*, 169(7), 659-665. doi: 10.1001/jamapediatrics.2015.0210

Emery CA, Black AM, Kolstad A, et al. (2017). What strategies can be used to effectively reduce the risk of concussion in sport? *British Journal of Sports Medicine*, 51, 978-984. doi: 10.1136/bjsports-2016-097452

Hershman, E.B., Anderson, R., Bergfeld, J.A., Bradley, J.P., Coughlin, M.J., Johnson, R.J., …, & Powell, J.W. (2012). An analysis of specific lower extremity injury rates on grass and field turf playing surfaces in National Football League games: 2000-2009 seasons. *American Journal of Sports Medicine*, 40(10), 2200 – 2205. doi:10.1177/0363546512458888

Houck, Z., Asken, B., Bauer, R., Pothast, J., Michaudet, C., & Clugston, J. (2016). Epidemiology of syndesmosis injuries in intercollegiate football: Incidence and risk factors from National Collegiate Athletic Association injury surveillance system data from 2004-2005 to 2008-2009. *American Journal of Sports Medicine, 44(9),* 2269 – 2275. doi:10.1177/0363546516645070

Iguchi, J., Yamada, Y., Kimura, M., Fujisawa, Y., Hojo, T., Kuzuhara, K., & Ichihasha, N. (2013). Injuries in a Japanese Division I collegiate American football team: A 3-season prospective study. *Journal of Athletic Training, 48(6),* 818-825. doi: 10.4085/1062-6050-48.4.15

Kerr, Z.Y., Simon, J.E., Grooms, D.R., Roos, K.G., Cohen, R.P., & Dompier, T.P. (2016). Epidemiology of football injuries in the National Collegiate Athletic Association, 2004-2005 to 2008-2009. *The Orthopaedic Journal of Sports Medicine, 3(7),* 1-8. doi: 10.1177/2325967115594578

Kerr, Z.Y., Hayden, R., Dompier, T.P., & Cohen, R. (2015). Association of equipment worn and concussion injury rates in National Collegiate Athletic Association football practices. *American Journal of Sports Medicine, 43(5)*, 1134-1141. doi: 10.1177/0363546515570622

Kerr, Z.Y., Yeargin, S., Valovich McLeod, T.C., Nittoli, V.C., Mensch, J., Dodge, T.,…, & Dompier, T.P. (2015). Comprehensive coach education and practice contact restriction guidelines result in lower injury rates in youth American football. Orthopaedic Journal of Sports Medicine, 3(7), 1-8. doi: 10.1177/2325967115594578

Kilcoyne, K.G., Dickens, J.F., Svoboda, S.J., Owens, B.D., Cameron, K.L., Sullivan, R.T., & Rue, J.P. (2014). Reported concussion rates for three Division I football programs: An evaluation of the new NCAA concussion policy. Sports Health, 6(5), 402-405. doi: 10.1177/194173811349545

Kontos, A.P., Elbin, R.J., Fazio-Sumrock, V.C., Burkhart, S., Swindell, H., Maroon, J., & Collins, M.W. (2013). Incidence of sports-related concussions among youth football players aged 8-12 years. *Journal of Pediatrics, 163(3),* 717-720. doi: 10.1016/j.peds.2013.04.011

Lawrence, D.W., Comper, P., Hutchison, M.G. (2016). Influence of extrinsic risk factors on National Football League injury rates. *Orthopaedic Journal of Sports Medicine, 4(3)*, 1-9. doi: 10.1177/2325967116639222

Lynch, T.S., Saltzman, M.D., Ghodasra, J.H., Bilimoria, K.Y., Bowen, M.K., & Nuber, G.W. (2013). Acromioclavicular joint injuries in the National Football League. *American Journal of Sports Medicine, 41(12)*, 2904-2908. doi: 10.1177/0363546513504284

McGowan Lowrey, K. & Morain, S.R. (2014). State experiences implementing youth sports concussion laws: Challenges, successes, and lessons for evaluating impact. *Journal of Law, Medicine, & Ethics*, 290-296.

McGuine, T.A., Hetzel, S., McCrea, M., & Brooks, M.A. (2014). Protective equipment and player characteristics associated with the incidence of sport-related concussion in high school football players: A multifactorial prospective study. *American Journal of Sports Medicine*, 42(10), 2470-2478. doi: 10.1177/0363546514541926

McGuine, T.A., Hetzel, S., Wilson, J., & Brooks, A. (2012). The effect of lace-up ankle braces on injury rates in high school football players. *American Journal of Sports Medicine, 40(1), 49-57.* doi: 10.1177/0363546511422332.

Myer, G.D., Smith, D., Barber Foss, K.D., Dicesare, C.A., Kiefer, A.W., Kushner, A.M., Thomas, S.M., …, & Khoury, J.C. (2014). Rates of concussion are lower in National Football League games played at higher altitudes. *Journal of Orthopaedic & Sports Physical Therapy*, 44(3), 164-172.

Nathanson, J.T., Connolly, J.G., Yuk, F., Gometz, A., Rasouli, J., Lovell, M., & Choudhri, T. (2016). Concussion incidence in professional football: Position-specific analysis with use of a novel metric. *Orthopaedic Journal of Sports Medicine, 4(1)*, 1-6. doi: 10.1177/2325967115622621

Teramoto, M., Petron, D.J., Cross, C.L., & Willick, S.E. (2015). Style of play and rate of concussions in the National Football League. *Orthopaedic Journal of Sports Medicine*, 3(12), 1-9. doi: 10.1177/2325967115620365

Thomson, A., Whiteley, R., & Bleakley, C. (2015). Higher shoe-surface interaction is associated with doubling of lower extremity injury risk in football codes: A systematic review and meta-analysis. *British Journal of Sports Medicine, 49,* 1245-1252. doi: 10.1136/bjsports-2014-094478

Westermann, R.W., Kerr, Z.Y., Wehr, P., & Amendola, A. (2016). Increasing lower extremity injury rates across the 2009-2010 to 2014-2015 seasons of National Collegiate Athletic Association football – an unintended consequence of the "Targeting" rule used to prevent concussions? *American Journal of Sports Medicine, 44(12),* 3230-3236. doi: 10.1177/0363546516659290

Williams, S., Hume, P.A., & Kara, S. (2011). A review of football injuries on third and fourth generation artificial turfs compared with natural turf. Sports Medicine, 41(11), 903-923.

Zuckerman, S.L., Kerr, Z.Y., Yengo-Kahn, A., Wasserman, E., Covassin, T., & Solomon, G.S. (2015). Epidemiology of sports-related concussion in NCAA athletes from 2009-2010 to 2013-2014 – incidence, recurrence, and mechanisms. *American Journal of Sports Medicine, 43(11)*, 2654-2662. doi: 10.1177/036354651559934