



Imaging and High School Sports in the Fall

- Participation in high school sports has been climbing steadily, with nearly eight million high school athletes on a team during the 2016-2017 year.
- The increase in participation has been accompanied by a marked rise in the incidence of sports-related injuries among high school athletes.
- Overuse injuries such as tendinopathy and stress fractures are common in various fall sports, and are exacerbated by growing trends including single-sport specialization and faster serve speeds in tennis.
- Football is also associated with a range of injuries: ligament sprains, muscle and tendon strains and concussions.
- Imaging plays varying roles in the diagnosis and treatment of the above injuries, with further applications in development. In addition, imaging research provides deeper insights into the mechanisms of the injuries.

Autumn has arrived, which means many high school athletes playing fall sports such as football, tennis and cross-country running will inevitably injure themselves in the coming weeks and months. This issue focuses on the incidence and types of these injuries and the role imaging can play in their diagnosis and treatment.

Increases in both participation and injury rates in high school sports

In the United States, the number of high school students participating in sports has been climbing over the past several decades. According to an annual High School Athletics Participation Survey conducted by the National Federation of State High School Associations (NFHS), the 2016-2017 school year marked the 28th consecutive year with an increase in the overall number of high school athletes – with an all-time high of nearly eight million students involved in sports. This steady rise in participation has been accompanied by an increase in single-sport specialization, which in turn has led to year-round, often intensive training in the sport in question without the variation in types of physical activity associated with distinct sports seasons (baseball in the spring, football in the fall, etc.).

The confluence of these factors has resulted in striking increases in sports-related injuries among high school athletes. The likelihood of suffering from such injuries is compounded by the students' stages of both physical and emotional development: *physical* because the growing musculoskeletal system is especially vulnerable to the types of stresses that can cause the injuries, and *emotional* because the young athletes may not always cognitively connect nebulous symptoms such as fatigue or poor performance with possible underlying injuries and therefore may not seek the appropriate care.

Overall Injuries from Football

Football remains one of the most popular high school sports despite the growing awareness of concussions and concerns about other related injuries. In the 2018-2019 school year, it led the list of top 10 participant sports for American high school boys, according to an annual survey published by the National Federation of State High School Associations. The report showed 1,006,013 boys played on their high school's tackle football team, making the 2018-2019 year the 20th year in a row with at least one million American high school football players. The next most popular sport for high school boys in the same year was track and field, with 605,354 participants in the US.

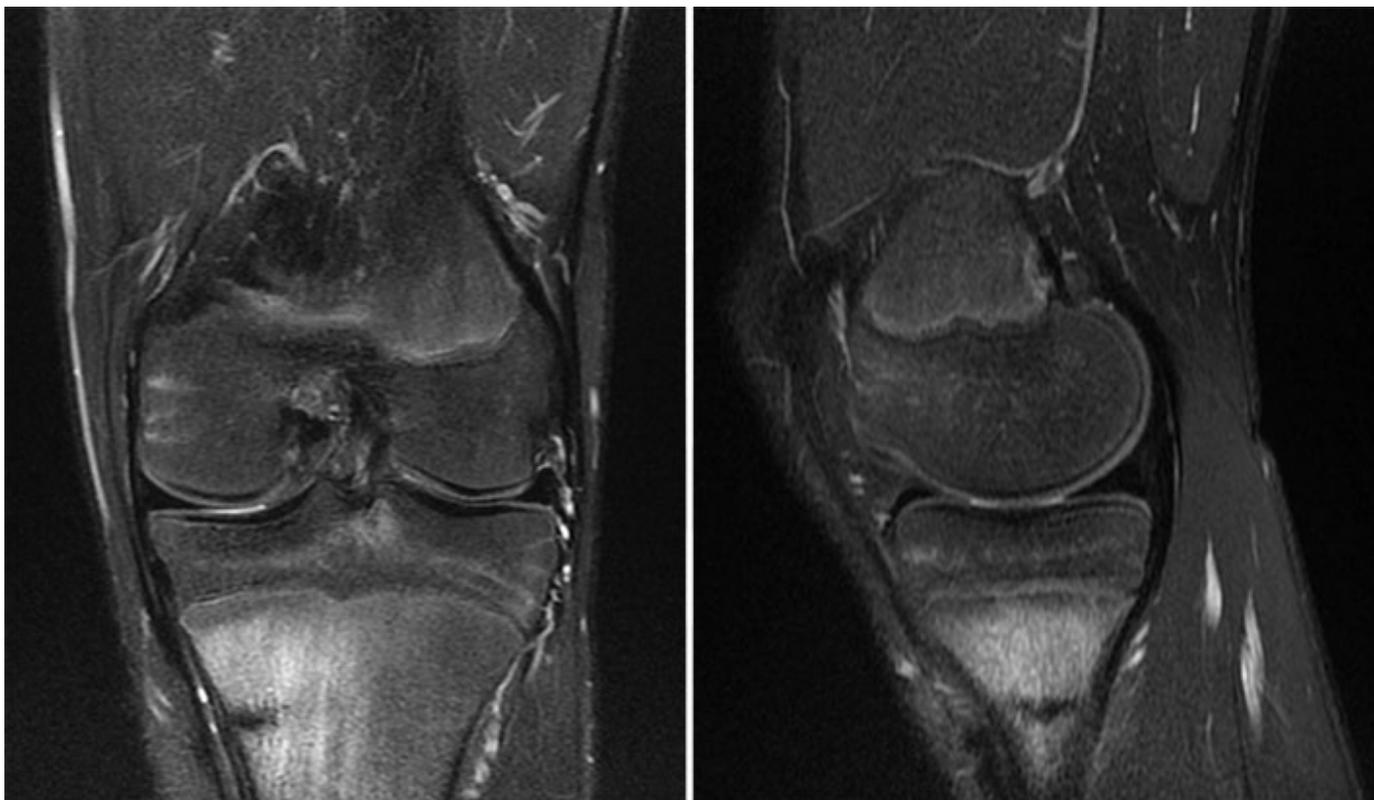


Figure 1: A 14-year-old male cross-country runner was experiencing knee pain. A knee MRI using T2 sequences revealed a stress fracture in the proximal tibia. Images courtesy of Randheer Shailam, MD, Pediatric Imaging, Department of Radiology, Massachusetts General Hospital.

Not only does high school football have the highest number of male participants, it also has the highest proportion of total injuries sustained: an average of 582,434 injuries every year, according to a 2018 study looking at the epidemiology of injuries in both high school and college football between the 2004-2005, 2005-2006 and 2013-2014 school years. The incidence of injuries in football is due to both the higher numbers of players than in other high school sports and greater injury rates among the players.

The study also examined the frequency of the different types of injuries sustained during competition as well as during practice. The most common diagnoses for injuries sustained during practice were ligament sprains (24.2%), muscle or tendon strains (18.1%) and concussions (15.8%). During competition, the most common diagnoses were ligament sprains (29.0%), concussions (20.4%) and contusions (14.9%). Perhaps not surprisingly, most injuries sustained during both practice and competition (56.7% and 74.5%, respectively) were due to player contact, including being on either side of tackling, on either side of blocking and other player-to-player mechanisms. Concussions in high school football players typically resulted from either being tackled or tackling.

As with overuse injuries, imaging plays varying roles in the diagnosis and management of injuries sustained in high school football. For example, MRI offers excellent sensitivity and specificity for imaging of high-grade ligament injuries, osteochondral defects, syndesmotic injuries and occult fractures. The modality isn't often used in acute settings, but clinicians may call on this type of imaging to diagnose underlying joint damage when symptoms persist.

Evaluation of Concussion

With respect to concussion, imaging isn't currently used for diagnosis since concussion is a functional disorder and imaging modalities such as magnetic resonance imaging (MRI) and computed tomography (CT) provide structural information. Use of imaging in concussion could change, though, with ongoing developments in modalities such as diffusion tensor imaging (DTI) and functional MRI (fMRI). DTI has been able to detect axonal damage by assessing the integrity of white matter tracts in the brain while fMRI can reveal abnormalities in cerebral oxygenation associated with concussion.

Overuse Injuries in Tennis and Volleyball

Fall sports lead to high incidences of overuse injuries especially in overhead sports such as tennis and volleyball. The increase in single-sport specialization with year-round training regimens has led to a growing concern about overuse injuries in high school athletes, not least because the athletes' developing skeletal systems are vulnerable to the repetitive and excessive stress associated with the regimens. Overuse injuries, which commonly include tendinopathy, stress reaction, stress fracture and juvenile osteochondritis dissecans, are especially pronounced in overhead sports.

In a paper published earlier this year in *Sports Translational Medicine*, researchers reported the incidence and prevalence of overuse injuries in high school sports. Their review of the literature revealed overuse injuries resulted most commonly from the fall sports of tennis, volleyball and baseball. In fact, the incidence and prevalence of such injuries were highest in tennis – far higher than in any other sport covered in the literature. The rates of overuse injuries in the shoulder were 5.30 per 10,000 athletic exposures (AE, defined as an athlete participating in one game or practice) as compared to 0.51-0.64 per 10,000 AE for baseball and 0.38 per 10,000 for volleyball. For overuse injuries of the elbow, the rates were 2.65 per 10,000 AE for tennis and 0.29-0.35 per 10,000 for baseball. The researchers noted several likely contributing factors to the high incidence of overuse injuries in tennis. Single-sport specialization is more common in youth tennis than in other overhead sports, for example, while serve speeds are getting faster, intensifying and exacerbating the strain on the athlete's elbows and shoulders.

Imaging plays varying roles in the diagnosis and management of overuse injuries. It can help in diagnosing stress fractures, for example, particularly in cases where uncertainty remains even after physical examination and consideration of the patient's clinical history. Physicians may also call on imaging to help guide treatment, using it to grade the severity of the injury. In these cases, the patient is likely to undergo MRI, which is widely considered the gold standard for evaluation of bony stress injuries. Clinicians will sometimes use CT to differentiate between lesions that might appear on bone scans as stress fractures.

Further Information

For more information about pediatric sports imaging, please contact [Randheer Shailam, MD](#), MassGeneral Hospital for Children. We would like to thank Dr. Shailam and Ona Wu, PhD, Athinoula A. Martinos Center for Biomedical Imaging, Massachusetts General Hospital, for their advice and assistance in preparing this article.

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