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CRITIQUE OF THE PSEUDO PLAYING SURFACES, SHOE-SURFACE INTERFACE, AND ATHLETES WITH LOWER EXTREMITY INJURIES

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ABSTRACT

The emergence of pseudo playing surfaces and synthetic pavement affected field use, shoe-surface dynamics, and the occurrence of sport-related injuries. Modern third generation turfs are being used globally in recreational enterprises and professional stadiums. The interface between both the shoe and the floor has a considerable impact on these injuries. Independent variables such as environmental conditions, contact vs. non-contact activity, shoe style and field wear complicate many of the outcomes available in the literature, thereby preventing an accurate evaluation of the true risk associated with such combinations of shoe surfaces. Traditionally, evidence exhibit a stronger frequency of injury is associated with artificial turf. Furthermore, robust biomechanical data show that both the torque and strain encountered by artificial surfaces generated by lower extremity joints may be worse than those generated by natural grass fields.

KEYWORDS: Independent variables such as environmental conditions, contact vs.

INTRODUCTION

Sports-related injuries are a significant burden in the health care system, with the yearly cost of treating injuries to high school athletes alone estimated to be > 2 billion.[1] Given the impact of these injuries, much effort has been devoted to studying the mechanisms underlying common sports-related injuries and how they can be prevented. One of the foremost vital variables is that the shoe-surface interface. Synthetic playing surfaces were

first introduced in the 1960s to provide children in inner cities with equal access to sports and other physical activities.[2] The overall costs and benefits of these surfaces remain a source of debate to this day. Proponents of synthetic turf suggest that it appears to provide a more consistent playing surface and its use is not weather dependent.[3] It also shows improved durability and low upkeep costs[4] Despite the proposed advantages of artificial turf, concerns regarding its impact on lower extremity injury rates have led to several studies on the subject during the past 40 years.[5-10] This review discusses the evolution of artificial surfaces and describes the biomechanics of the shoe-surface interface. It further discusses some of the most common turf-related lower extremity injuries and reviews the current literature.

THE HISTORY OF ARTIFICIAL TURF

First-generation playing surfaces: These are developed in the 1960s (e.g. AstroTurf, AstroTurf, LLC) comprised a dense carpet matrix.[3] They were usually constructed from durable nylon fibers (10–12 mm in length), and no filler substance was used. This surface had several faults: it caused high levels of skin abrasion ("turf-burn") and high ball bounce[3] due to the absence of padding to absorb the impact. This was later corrected by adding a shock-absorbing pad below the playing surface. The surfaces were also sprayed with water to limit friction and reduce skin abrasion.

Second-generation playing surfaces: These were constructed from a softer polyethylene material, with longer fibers that were spaced farther apart to facilitate the use of a filler substance, usually sand. The sand filler provided a softer, more uniform surface, and a more consistent and "natural" ball-bounce and roll[3].Around this time (the 1970s), "turf shoes" were introduced to the marketplace as an alternative to cleated sports shoes. These shoes were touted as providing a better interface with the new playing surface than the more traditional cleated and flat-bottomed shoes.[10]

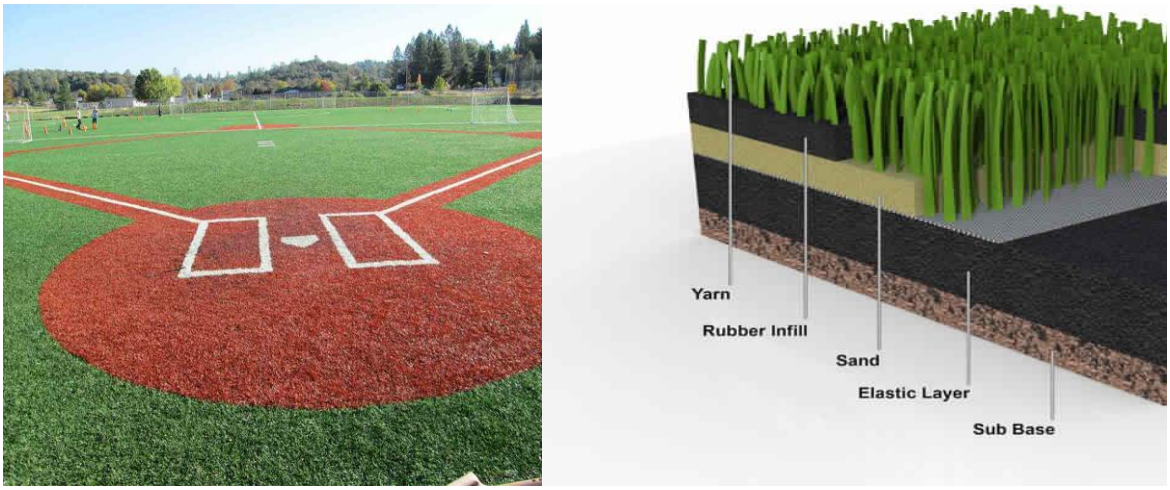
Third-generation artificial surfaces (e.g. Field Turf, Tarkett Sports): these are designed to more closely replicate natural grass with regard to shoe-surface interaction and fiber morphology. The fibers are longer than those used in second-generation surfaces, and there is more space between fibers. New fillers are used, consisting of a base layer of sand and rubberized particles, to better replicate the dirt that exists between blades of grass, providing athletes with a more comfortable and natural feel during play. However, despite these advances in turf development, the effects of artificial surfaces on the incidence of sports-related lower extremity injuries remain controversial.[8,9,11]

TYPES OF TURF

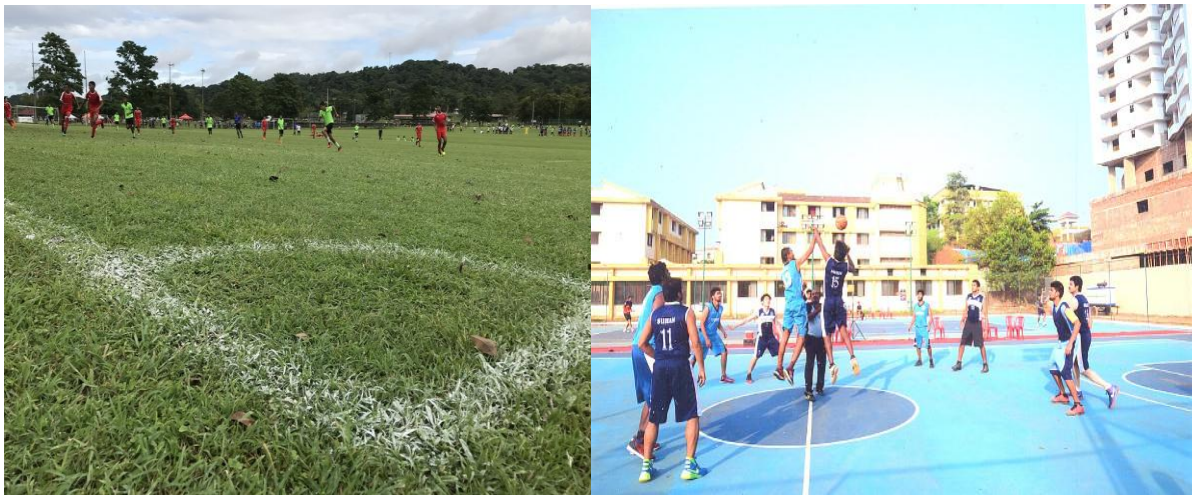
- Astroturf
- Super turf
- Field turf

Among these, field turf is the most popular and is used extensively in athletic fields and stadiums. Astroturf is the oldest and most recognised name in industries, but newer and most friendly type turfs are used recent years.

The primary difference of three surface is the material used in their production that are often composed of sand or cream rubber that is used to soften the surface of the turf. the deeper the infill the harder the turf will feel to the players on the field.



Artificial turf surface Layers of artificial surfaces



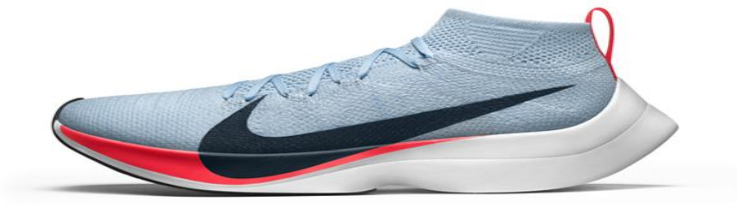
Natural playing surface

SYNTHETIC PLAYING SURFACE

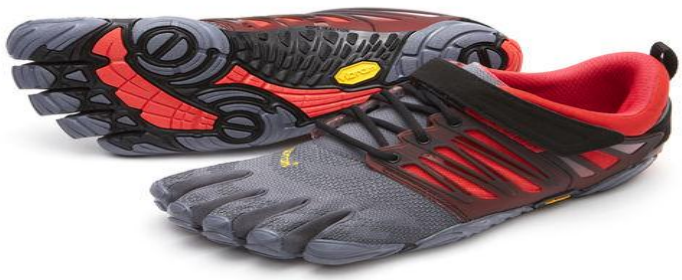
TYPES OF ATHLETIC SHOES

- Running Shoes
- Barefoot Running Shoes
- Cross Trainers
- Court Shoe
- Cleat shoes
- Hiking Shoes

Running Shoes

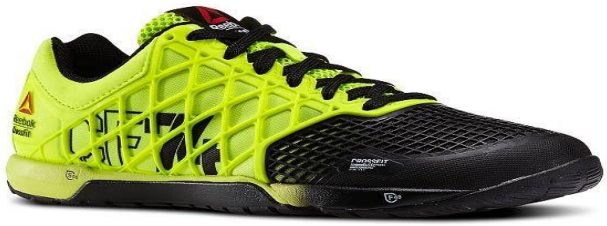


Barefoot Running Shoes: Running without shoes or barefoot running is growing in popularity. A professional trainer will tell you if this sort of running is a good selection for you, and if so, provide you a tips and exercises to help you safely and slowly transition from running in shoes to running barefoot.[19]

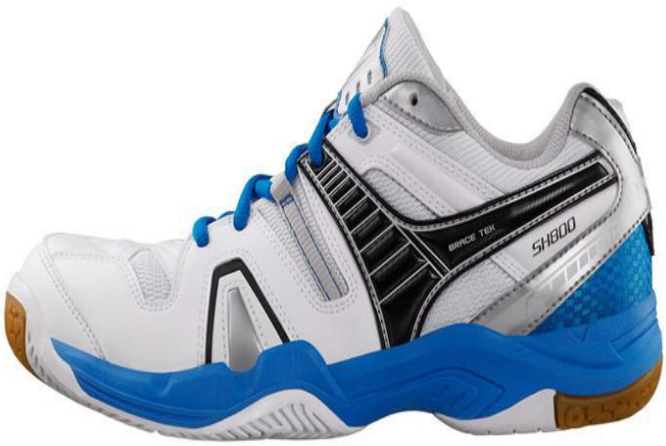


Cross Trainers: A cross training shoe is designed for multiple use you can use them in the gym for almost any activity. This type of shoe is not appropriate for someone who plans on

running more than four to five miles a day. A cross trainer shoe is usually made of a combination of mesh materials and strips of leather in the fabric. If the shoe has a "running" tread on the sole, it might be difficult to wear the shoe on a court for an exercise class or game.



Court Shoe: Court shoes include those designed for basketball, tennis, and volleyball. Court shoes have a solid tread and typically are made of soft leathers. They are designed to provide stability in all directions.



Cleats: Many sports, such as soccer, lacrosse, football and baseball, require the athlete to wear a cleat shoe. Shoes with cleats (also called spikes or studs) have multiple protrusions made of steel or hard plastic that provide additional traction on grass or soft turf.[12,18] There are different types of cleats for different sports, so it is important to consult with a coach or professional before purchasing a new cleat shoe. Cleats tend to run narrow so if you wear an

orthotic (a shoe insertion to provide added support), or plan on putting an extra insole in the cleat, you may want to purchase a brand that is known to have a wider cut.

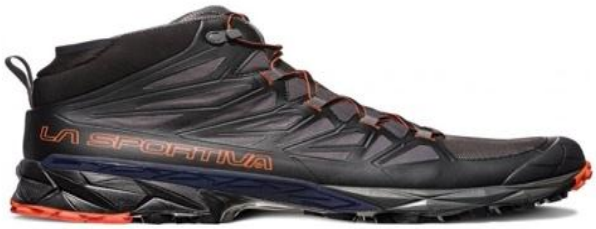
Lacrosse cleats: It has a high upper around the ankle for added stability since much of the game involves running quickly, changing directions, and performing start/stop maneuvers on grass or turf. They are designed like a football cleat in that they have a centre front toe cleat to provide traction when moving forward. Lacrosse cleats have a more supportive midsole than a football cleat. A lacrosse cleat is most often molded onto the outer edge of the sole versus under the ball of the foot.

Football cleats: it is different from soccer cleats in that they have a centre toe cleat that improves traction during quick starts. Football cleats typically have a stiffer outsole than lacrosse cleats. A football cleat will have spikes or studs that can be removed from the outer sole, or those that are molded to the shoe.

S*pikes:* This are usually preferred on a grass or field turf surface, allowing a player to dig into the surface and resist forces that may stop forward movement. Removable cleats are advantageous because they can be switched out for different surfaces. They come in 1/2, 5/8, 3/4, and 1 inch sizes. Molded cleats are preferred on turf surfaces to provide more traction. A running back or wide receiver may prefer a low cut cleat providing greater agility on the field while performing cutting maneuvers.

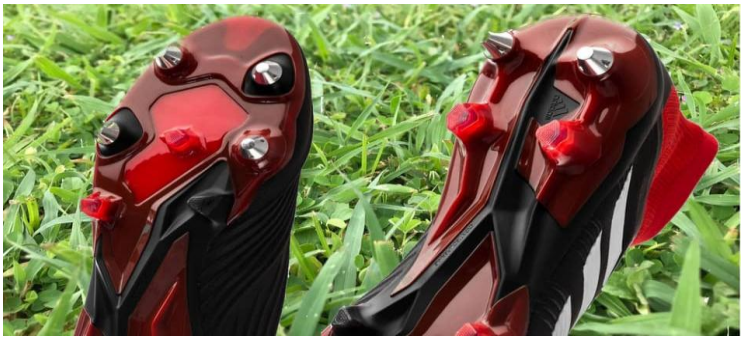
Baseball cleats: it has longer/narrower cleats that are attached to the sole of the shoe. Baseball cleats also have a toe spike to provide traction when taking off from a base and running in dirt. These spikes are often made of steel versus the molded plastic studs in other cleats.

Hiking Shoes: A hiking shoe needs to provide stability as you walk across uneven surfaces, as well as comfort and cushion in the insole to absorb the shock from various impacts. Hiking shoes also should have a good tread on the sole to keep your foot firmly planted on the surfaces that you encounter.



Shoe-Surface Interface: Shoe-surface interface represents the interplay between intrinsic and extrinsic factors[12] Intrinsic factors are those pertaining to the athlete's build and movement (e.g., body weight, velocity, acceleration, loading rate, foot angle [foot stance], and height) before any surface contact is taken into account. Extrinsic factors include footwear, the playing surface, and environmental factors.[3,12] Extrinsic Factors contained of many different shoe designs and cleat patterns have been developed over the years. The conventional cleated football shoe has 7 cleats, each measuring 3/4 inch in length. Alternatively, the conventional soccer shoe has 12 short molded cleats, ranging from 3/8 to 1/2 inch in both length and tip diameter. The "swivel shoe" it consist of swivel plate prevent the foot from being fixed, but has cleats on the forefoot area. The "pivot disc" shoe modification contains a 10-cm circular plate on the forefoot and a central cleat, but retains a full set of heel cleats. the "turf shoe" has a dense pattern of short elastomeric studs, which are distributed evenly over the entire sole. Finally, conventional non cleated court shoes, such as basketball shoes, tennis shoes, and running sneakers, have flat soles.[13,14] New-generation turf shoes have now been developed, which include midsole cushioning to further dissipate the forces generated by ground contact.[14,15]

Cleat shape can influence the shoe-surface interaction. Cleats are classified as edge-type, bladed, conical, cup-shaped, tapered, triangular, or elliptical.[7] Furthermore, cleats can be made from elastomeric or thermoplastic polyurethane (TPU) materials or from steel-tipped TPU.[14]



- Bonstingl et al[13] showed that the swivel shoe generated considerably lower torque in the toe stance position than any other shoe type, regardless of the playing surface. This suggests that turf shoes generate a lower peak torque than other shoe types (on all surfaces) due to the limited capacity of the short cleats to penetrate the infill layer in the artificial turf or the soil in a natural surface. However, these results are not in agreement with those reported by Livesay et al[17] and Cawley et al[12], who showed that turf shoes generated higher torques and showed greater rotational stiffness than any other shoe when used on an artificial surface.

- Heidt et al[18] reported that both conventional cleated football shoes and turf shoes generate significantly higher rotational torques than either soccer shoes or noncleated shoes when used on both natural surface and artificial turf. Based on these studies, one may conclude that the high torques that develop when cleated shoes are used on artificial turf are related to the greater total effective area involved in cleat surface contact, which is proportional to cleat number, length, and size.[12,13,16,19]

- Although the sole material used for noncleated shoes has a minimal effect on torque generation[13], Villwock et al[14] reported that the sole material used for cleated shoes has a significant effect on rotational stiffness. Shoes with rigid upper soles have a significantly higher rotational stiffness than shoes with pliable soles. The cleat material also makes a difference. Polypropylene cleats generate lower torques than polyurethane or rubber-like cleats and soles.[20] In addition to the cleat and sole materials, the pattern and shape of the cleats has a significant impact on the amount of torque developed at the shoe-surface interface. Shoes with more cleats on the heel than on the forefoot generate lower torques than shoes with more cleats on the forefoot than the heel.[20] Shoes with cleats located on the periphery of the sole generate significantly higher levels of torque than other designs, including soccer-type flat cleats, conical cleats, and pivot disc cleat; they are also associated with a significantly higher number of anterior cruciate ligament (ACL) injuries.[21] Queen et

al[15] found that the small cleats used in turf shoes resulted in less pressure on the plantar aspect of the foot, specifically the area beneath the metatarsal heads. They hypothesized that this could potentially minimize the occurrence of metatarsal stress fractures. Unfortunately, the sheer number of cleat patterns, materials, and sizes available in the marketplace prevents robust longitudinal studies from being performed, making it difficult to derive any firm, evidence-based conclusions.

Overall, the incidences of minor, substantial, and severe injuries were significantly lower on Field Turf. However, not all studies reach the same conclusions. Data obtained from the National Football League (NFL) Injury Surveillance System (ISS) (which investigates game-related injuries) between 2002 and 2008 shows that the injury rate per team game was 27% higher on Field Turf than on natural grass.[11,22] This was most evident for ACL injuries and eversion ankle injuries, which occurred more frequently (88% and 48%, respectively) on Field Turf than on natural playing surfaces. The authors found no significant differences in the rates of inversion ankle sprains or medial collateral ligament (MCL) sprains occurring on synthetic surfaces or natural grass. There is an interesting correlation between the incidence of surface-related injuries and playing at the elite level. One may infer that the more elite players (typically represented by NFL players) generate higher peak torques and strain because they carry more mass and generate more power than high school and college players

LOWER EXTREMITY TURF-RELATED INJURIES

Foot and ankle injury: Nearly 25% of all injuries sustained by athletes are related to the foot and ankle.[23] Game-related ankle injuries account for 15.6% 29 of the injuries sustained by male National Collegiate Athletic Association (NCAA) football players, 16.95%[25] of the injuries sustained by male and female lacrosse players, and 19.1%[24] of the injuries sustained by male and female soccer players (according to the NCAA ISS). By contrast, foot injuries represent a much smaller percentage, averaging 1.86% across these sports.[24,25]

***Turf Toe*:** Hyperextension injury of the metatarsophalangeal (MP) joint of the great toe is often referred to as "turf toe"[6] and is relatively common in football players. The toe is most vulnerable to this injury when in dorsiflexion at the same time as the foot is in plantar flexion; any axial load then applied (e.g., an offensive lineman falling onto the back of another player's heel) will force the great toe into hyperextension. Flexible shoes and hard playing surfaces are thought to be risk factors.[6] Turf toe causes pain, disability, and varying

degrees of instability. Patients typically describe an acute injury and present with pain and swelling of the metatarsophalangeal joint of the great toe.

Turf toe injuries are classified into 1 of 3 grades, which help to further management strategy.

- *Grade I injuries:* involve localized swelling and ecchymosis, representing attenuation of the soft tissue–supporting structures. Patients are treated symptomatically and can return to play when able.
- *Grade II injuries:* patient present with a pain-limited range of motion, with moderate swelling of the great toe due to a partial tear of the plantar capsule ligamentous structures. These patients are treated with short-term (2–4 weeks) immobilization in a walking boot or a hard-sole shoe.
- *Grade III injuries:* are the most severe. Complete disruption of the soft tissue structures leads to large-scale swelling and ecchymosis, weakness of metatarsophalangeal flexion, and gross instability. These patients are treated with long-term immobilization (10–16 weeks) in a walking boot or hard-sole shoe, and may be considered for surgical intervention. Full recovery after surgical repair may take up to 1 year.[27]

Ankle Ligament Injuries

- The classic ankle sprain results from an inversion or "rolling" motion of the foot relative to the tibia and causes injury to the lateral stabilizing ligaments. Hootman et al evaluated the NCAA ISS data and found that ankle ligament sprains were the most common injury, accounting for 14.9% of all injuries.
- Ekstrand et al evaluated 290 elite European soccer players who played on third-generation turf and compared their injuries with those sustained by 202 players from the Swedish Premier League who played on natural grass. They found no relationship between the playing surface and the incidence of injury. They did, however, report a higher incidence of ankle sprains in players competing on artificial turf, but cautioned against drawing any conclusions; rather, they suggested that further investigations were needed given the small number of ankle injuries sustained by the study participants.
- Williams et al reported a significantly increased risk of ankle injury in rugby, soccer, and American football players playing on third-generation artificial turf compared with natural grass. A "high ankle sprain" is an eversion injury of the ankle mortise resulting in disruption of the tibiofibular syndesmosis.[26] High ankle sprains injuries tend to be

associated with artificial playing surfaces. Although these injuries are relatively uncommon, they result in prolonged disability.[28]

- A high ankle sprain usually occurs when an athlete is struck on the outside of the leg while the foot is firmly planted. Signs include swelling, ecchymosis, tenderness on palpation of the syndesmosis, and a positive squeeze test.[28] Radiographs can help to classify the injury and guide the management strategy. National Football League ISS data from 2010 suggest that this type of ankle injury has a 48% higher incidence on FieldTurf compared with natural grass.[22]

KNEE INJURIES

- Darrow et al examined the incidence of sports-related injuries in 100 high schools in the United States from 2005 to 2007. They found that knee injuries were the most common, accounting for 29% of severe injuries. In the NFL, an average of 6 game-related knee ligament injures occur per team per season.[12] Powell and Schootman[12] reported that between 1980 and 1989, NFL players sustained knee sprains more frequently on synthetic surfaces than on natural grass.
- Hershman et al also found a difference in the incidence of knee injuries sustained on artificial and natural playing surfaces[22], reporting an 88% increase in game-related ACL injuries in NFL players competing on Field Turf.
- Drakos et al used a cadaver model to measure the degree of ACL strain imparted by a simulated “cut” (simultaneous axial loading and internal rotation of the femur) under different shoe-surface conditions. Significantly less stress (P, 0.5) was measured in the anteromedial bundle of the ACL when the subject was wearing cleats on a natural grass surface. They concluded that this shoe-surface interface may result in fewer noncontact ACL injuries due to the reduced stress placed on the ACL.
- A literature review conducted by Williams et al found no consistent association between the playing surface (third-generation turf vs natural grass) and the incidence of knee injuries.[26]
- Meyers and Barnhill reported a higher incidence of knee sprain/MCL injuries in high school football players playing on Field Turf than in those playing on natural grass.[9] However, they also reported a trend toward higher rates of ACL injury on natural grass than on synthetic surfaces, although the result was not statistically significant.[11]

CONCLUSION

Biomechanical studies indicate that the shoe-surface interface has a significant impact on the incidence and type of sport-related injury suggesting that the amount of torque and subsequent strain generated when playing on artificial surfaces is greater than that generated when playing on natural grass. Older studies of early-generation synthetic turf suggested that artificial surfaces were associated with higher injury rates. The clinical review depend on the many different variable, such as weather conditions, the mechanism of injury, the type of shoe worn by the athlete, and field wear. Furthermore, recent studies of third-generation turf suggest a possible correlation between the incidence of injury and the level of play (elite vs amateur). The studies has report that less severe injuries are sustained by high school athletes playing on Field-Turf than those playing on natural grass, with a more rapid return to play after injury. In a separate study that evaluated college athletes, the authors reported that, overall, third-generation synthetic playing surfaces were associated with lower injury rates. Some other study reported that NFL players sustained significantly higher rates of ACL and eversion ankle injuries when playing on Field-Turf.

REFERENCES

1. Goldberg AS, Moroz L, Smith A, Ganley T. Injury surveillance in Young-athletes: a clinician's guide to sports injury literature. Sports Med, 2007; 37(3): 265–278e.
2. Levy IM, Skovron ML, Agel J. Living with artificial grass: a knowledge update. Part 1: basic science. *Am J Sports Med,* 1990; 18(4): 406–412.
3. Fleming P. Artificial turf systems for sport surfaces: current knowledge and research needs. J Sport Eng Tech, 2011; 225(2): 43–63.
4. Tarkett sports. Field-Turf cost analysis. http: //www.fieldturf.com/ football-turf/cost-analysis/. Accessed March 3, 2012.
5. Adkison JW, Requa RK, Garrick JG. Injury rates in high school football. A comparison of synthetic surfaces and grass fields. *Clin Orthop Relat Res,* 1974; (99): 131–136.
6. Bowers KD Jr, Martin RB. Turf-toe: a shoe-surface related football injury. *Med Sci Sports,* 1976; 8(2): 81–83.
7. Culpepper MI, Niemann KM. An investigation of the shoe-turf interface using different types of shoes on poly-turf and Astro-turf: torque and release coefficients. *Ala J Med Sci,* 1983; 20(4): 387–390.

8. 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; 38(4): 687–697.
9. 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; 32(7): 1626–1638.
10. Powell JW, Schootman M. A multivariate risk analysis of selected playing surfaces in the national football league: 1980 to 1989. An epidemiologic study of knee injuries. *Am J Sports Med*, 1992; 20(6): 686–694.
11 Hershman EB, Anderson R, Bergfeld JA, et al. An analysis of specific lower extremity injury rates on grass and FieldTurf playing surfaces in national football league games: 2000–2009 seasons. *Am J Sports Med*, 2012; 40(10): 2200–2205.
12 Cawley PW, Heidt RS Jr, Scranton PE Jr, Losse GM, Howard ME. Physiologic axial load, frictional resistance, and the football shoe-surface interface. *Foot Ankle Int*, 2003; 24(7): 551–556.
13 Bonstingl RW, Morehouse CA, Niebel BW. Torques developed by different types of shoes on various playing surfaces. *Med Sci Sports*, 1975; 7(2): 127–131.
14 Villwock MR, Meyer EG, Powell JW, Fouty AJ, Haut RC. Football playing surface and shoe design affect rotational traction. *Am J Sports Med*, 2009; 37(3): 518–525.
15 Queen RM, Charnock BL, Garrett WE Jr, Hardaker WM, Sims EL, Moorman CT 3rd. A comparison of cleat types during two football-specific tasks on FieldTurf. *Br J Sports Med*, 2008; 42(4): 278–284; discussion 284.
16 Torg JS, Quedenfeld TC, Landau S. The shoe-surface interface and its relationship to football knee injuries. *J Sports Med*, 1974; 2(5): 261–269.
17 Livesay GA, Reda DR, Nauman EA. Peak torque and rotational stiffness developed at the shoe-surface interface: the effect of shoe type and playing surface. *Am J Sports Med*, 2006; 34(3): 415–422.
18 Heidt RS Jr, Dormer SG, Cawley PW, Scranton PE Jr, Losse G, Howard M. Differences in friction and torsional resistance in athletic shoe-turf surface interfaces. *Am J Sports Med*, 1996; 24(6): 834–842.
19 Torg JS, Quedenfeld T. Effect of shoe type and cleat length on incidence and severity of knee injuries among high school football players. *Res Q*, 1971; 42(2): 203–211.
20 Andréasson G, Linden Berger U, Renström P, Peterson L. Torque developed at simulated sliding between sport shoes and an artificial turf. *Am J Sports Med*, 1986; 14(3): 225–230.

21 Lambson RB, Barnhill BS, Higgins RW. Football cleat design and its effect on anterior cruciate ligament injuries. A three-year prospective study. *Am J Sports Med*, 1996; 24(2): 155-159.

22 Hershman E, Powel J, Bergfeld J, Spindler K, Wojtys E, Bradley J. American professional football games played on FieldTurf have higher lower extremity injury rates. *Am J Sports Med*, 2012; 40(10): 2200–2205.

23 Garrick JG, Requa RK. The epidemiology of foot and ankle injuries in sports. *Clin Sports Med*, 1988; 7(1): 29–36.

24 Dick R, Ferrara MS, Agel J, et al. Descriptive epidemiology of collegiate men's football injuries: National Collegiate Athletic Association injury surveillance system, 1988–1989 through 2003–2004. *J Athl Train*, 2007; 42(2): 221–233.

25 Dick R, Romani WA, Agel J, Case JG, Marshall SW. Descriptive epidemiology of collegiate men's lacrosse injuries: National Collegiate Athletic Association Injury Surveillance System, 1988–1989 through 2003–2004. *J Athl Train*, 2007; 42(2): 255–261.

26 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; 41(11): 903–923.

27 Anderson RB, Hunt KJ, McCormick JJ. Management of common sports-related injuries about the foot and ankle. *J Am Acad Orthop Surg*, 2010; 18(9): 546–556.

28 Hopkinson WJ, St Pierre P, Ryan JB, Wheeler JH. Syndesmosis sprains of the ankle. *Foot Ankle*, 1990; 10(6): 325–330.