

Higher Rates of Lower Extremity Injury on Synthetic Turf Compared With Natural Turf Among National Football League Athletes

Epidemiologic Confirmation of a Biomechanical Hypothesis

Christina D. Mack,^{*y} PhD, MSPH, Elliott B. Hershman,^z MD, Robert B. Anderson,[§] MD, Michael J. Coughlin,^{k{} MD, Andrew S. McNitt,[#] PhD, Rachel R. Sendor,^y MPH, and Richard W. Kent,^{**} PhD

Investigation performed at IQVIA, Research Triangle Park, North Carolina, USA

Methods: Lower extremity injuries reported during 2012-2016 regular season games were included, with all 32 NFL teams reporting injuries under mandated, consistent data collection guidelines.

Results: Play on synthetic turf resulted in a 16% increase in lower extremity injuries per play than that on natural turf. The higher rate of injury on synthetic turf was notably stronger when injuries were restricted to noncontact/surface contact injuries (IRRs, 1.20-2.03; all statistically significant). (+20-103%)

SUMMARY OF NON-CONTACT LOWER EXTREMITY INJURIES: (i.e. injuries incurred by surface interaction)

27% overall higher injury rate on synthetic turf vs. natural

56% higher rate – knee, ankle, foot – any time loss from injury

67% higher rate – knee, ankle, foot – >8 days' time loss from injury

45-46% higher rate – knee – any time loss from injury / >8 days' time loss from injury

68% higher rate – ankle, foot – any time loss from injury

103% higher rate – ankle, foot > 8 days time loss

When athletic training staff labeled contact with another player as the mechanism, there was no observed difference in injury rate between surface types. These findings add confidence to the conclusion that the field surface has an effect on lower extremity injury.

Biomechanical testing of various football cleats on a variety of athletic surfaces has clearly shown differences between natural and synthetic turf in terms of the ability to create a divot, thereby releasing the cleat at loading magnitudes and rates generated during elite athletic competition.

These biomechanical findings support the hypothesis that injury risk is greater on contemporary synthetic turfs than on natural turfs when loading from the turf through the shoe is a contributory mechanism to the injury in question. Previous assessments of the differential injury rate between synthetic and natural turfs did not explicitly explore this hypothesis, but results are generally supportive of it. Specifically, studies that focused on lower extremity injuries caused by a twisting or shearing mechanism showed greater rates of injury on synthetic versus natural turf. Synthetic surfaces lack the ability to release a cleat in a potentially

injurious overload situation and therefore can generate much greater shear force and torque on the foot and throughout the lower extremity.

Injury reporting is mandated across all 32 NFL teams within an electronic health record system in a robust and consistent manner, thereby eliminating the potential selection bias and variability inherent in similar studies. Injuries and the circumstances surrounding them (contact, impact, activity) are reported with necessary resolution to isolate injury type and mechanism in a structured manner during the course of clinical care by trained medical staff. Data are subject to quality control procedures over the course of the season, and the database is then linked to sport-related information, such as game day weather and surface conditions. Thus, these data represent comprehensive, clinically detailed reports of injuries sustained by a well defined population of elite athletes in well-documented conditions. Injuries that occurred during practices or during games outside the regular season were excluded from the analysis to minimize heterogeneity in the surfaces and player population considered.

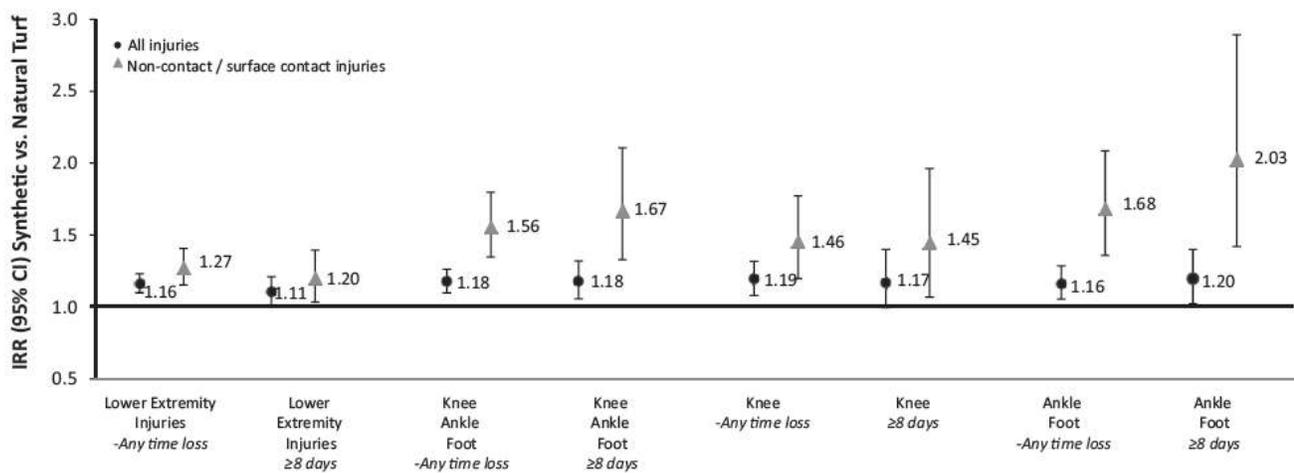
Although there is mechanical variability among natural turf species and among synthetic turf designs, testing showed that this intratype variability is small as compared with the intertype variability between natural turfs and synthetic turfs en bloc.²² Furthermore, aggregation of all NFL fields into either of those 2 categories is functionally justified, as it comports with analysis of the hypothesized biomechanical mechanism— specifically, natural turf divoting in a way that mitigates injury risk as compared with synthetic surfaces. All NFL turfs classified as “natural” are able to divot or otherwise sustain damage during play, and all of the turfs deemed “synthetic” are not.

RESULTS

Over the 5 seasons of data collection, 1280 NFL games were played: 555 (93,019 distinct plays) on synthetic surfaces and 725 (120,916 distinct plays) on natural surfaces. The rate of distinct plays per game, regardless of injury incidence, was 167.6 on synthetic and 166.8 on natural. A total of 4801 lower extremity injuries occurred, affecting 2032 NFL players.

The (surface/injury) association was particularly notable when restricted to noncontact/surface contact injuries, with IRRs (95% CIs) of 1.27 (1.15-1.41) across all lower extremity injuries, 1.46 (1.20-1.77) for knee injuries, and 1.68 (1.36-2.08) for ankle/foot injuries. Results were consistent for injuries with ≥ 8 days missed, increasing to an IRR as high as 2.03 (1.42-2.89) for ankle/foot injuries. The differential injury rate between synthetic and natural surfaces became more pronounced for groupings of noncontact/ surface contact injuries located more distally (ie, closer to the playing surface).

(continued)



SUMMARY OF NON-CONTACT LOWER EXTREMITY INJURIES: (i.e. injuries incurred by surface interaction)

27% overall higher injury rate on synthetic turf vs. natural

56% higher rate – knee, ankle, foot – any time loss from injury

67% higher rate – knee, ankle, foot – >8 days' time loss from injury

45-46% higher rate – knee – any time loss from injury / >8 days' time loss from injury

68% higher rate –ankle, foot –any time loss from injury

103% higher rate – ankle, foot > 8 days time loss

DISCUSSION

Among NFL athletes playing in 2012-2016 regular season games, higher rates of lower extremity injury occurred on synthetic turf than on natural turf. These results are consistent with 2000-2009 NFL findings¹⁵ and with the majority of studies among collegiate football players.^{6,8,13,16,18} Two football-related studies did not observe a difference between surface types among lower extremity injuries. with publicly reported NFL data,^{7,24} and 3 National Collegiate Athletic Association studies conducted with football and soccer players³²⁻³⁴ reported lower rates of injury on 1 brand of synthetic turf (FieldTurf) as compared with natural turf. The latter studies aggregated injuries across the body without targeting the lower extremity injury groupings related to the biomechanical hypothesis here.

When athletic training staff labeled contact with another player as the mechanism, there was no observed difference in injury rate between surface types. These findings add confidence to the conclusion that the field surface has a causal effect on lower extremity injury.

Synthetic turf must also advance toward allowing the cleat to release more readily at potentially injurious loading levels. As devoting or other damage to the synthetic surface is unlikely to be a viable mechanism of load limiting, additional research on the functional mechanics of cleat release, shoe-turf interactions, lower extremity injury biomechanics, and natural turf divoting would facilitate this design evolution. A second

indication is the continued refinement of cleat patterns and a comprehensive, collaborative consideration of cleat-turf interaction by producers of football shoes and synthetic turfs.

Until shoe and synthetic turf designs evolve to the point that the lower limb injury rate approaches that on natural turf, players and trainers may consider additional lower limb protection when on synthetic turf.

Future research should consider such countermeasures in addition to enhanced shoe and surface designs.

As infill is removed or displaced during the use of a synthetic field, longer lengths of fiber are exposed, which can increase the shear force and torque capacity of the synthetic surface by engagement with a cleat and possibly increase the risk of certain injuries. **More biomechanical research is warranted focusing on the shoe cleat–surface interaction.** Additional studies are underway examining variability among artificial surfaces and how factors such as age of field, infill depth and composition, and fiber density may affect injury.

CONCLUSION

Play on synthetic turf resulted in 16% more injuries per play than that on natural turf (IRR, 1.16; 95% CI, 1.10- 1.23) across all lower extremity injuries causing a player to miss any football participation—an association that became more pronounced as analytics focused on injuries located more distally (ie, nominally closer to the playing surface).

The association was particularly notable when noncontact/surface contact injuries were examined, increasing to 2.03 (1.42-2.89) for ankle and foot injuries resulting in 8 days missed from football participation. **The significance and nature of these associations add confidence to the conclusion that the field surface has a causal effect on injury that is related to a lack of release between a player’s shoe and a synthetic turf surface, which implies that the selection of footwear is critical from an injury mitigation standpoint, especially on synthetic surfaces.**