

Shoe-Surface Interaction and Lower Extremity Injury Risk in Sports: Balancing Performance and Safety

Introduction:

Lower extremity injuries are common in both field and court sports, especially during movements like cutting, pivoting, and landing. These non-contact injuries are often influenced by how the foot interacts with the playing surface. Footwear and surface type together determine traction, or how much grip exists between the shoe and the ground. While traction is necessary for performance, too much can increase stress on the joints and raise injury risk, while too little can reduce stability. Understanding this balance is key to improving both performance and athlete safety.

Purpose:

- Examine how footwear + surface type influence injury risk
- Identify balance between performance and safety

Shoe-Surface Interaction & Injury Risk

- Traction = grip between shoe + surface
- Includes:
 - resistance to slipping
 - resistance to rotation
- Increased traction:
 - improves performance
 - BUT $\uparrow$ joint stress
- Foot fixation:
 - foot sticks, body rotates
 - $\uparrow$ ACL injury risk (Dowling & Andriacchi, 2018)
- Research shows:
 - turf + cleats $\rightarrow$ $\uparrow$ rotational resistance
 - alters biomechanics (Shorten et al.; Villwock et al.)

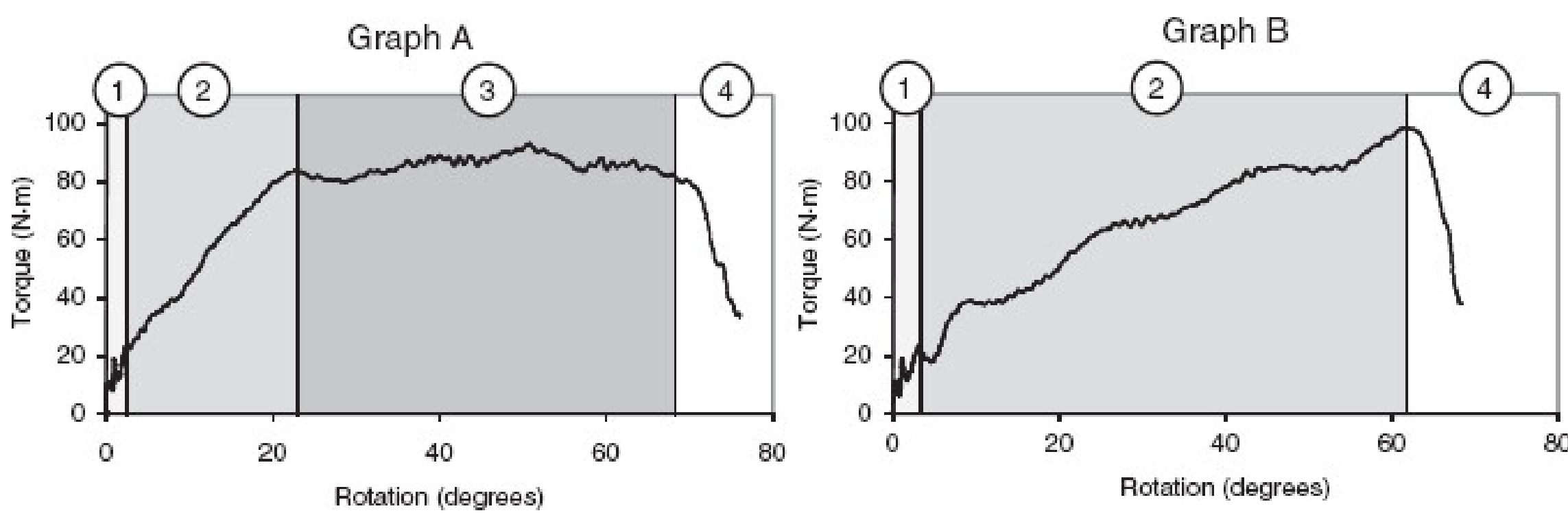


Figure 2 Representative shapes of the torque versus shoe rotation data. A, 4-region plot (initial breakaway, buildup, slippage, unloading); B, 3-region plot (omission of slippage). The percentage of rotation that occurred in each region was dependent on the shoe-surface combination and varied between shoes and surfaces.

Footwear Design in Sport:

- Different sports require different footwear
- Cleats $\rightarrow$ penetrate surface ($\uparrow$ traction)
- Court shoes $\rightarrow$ rely on friction
- Aggressive cleats:
 - $\uparrow$ rotational traction
 - $\uparrow$ joint loading (Villwock et al., 2009)
- Cushioning affects impact forces (Low & Dixon, 2016)

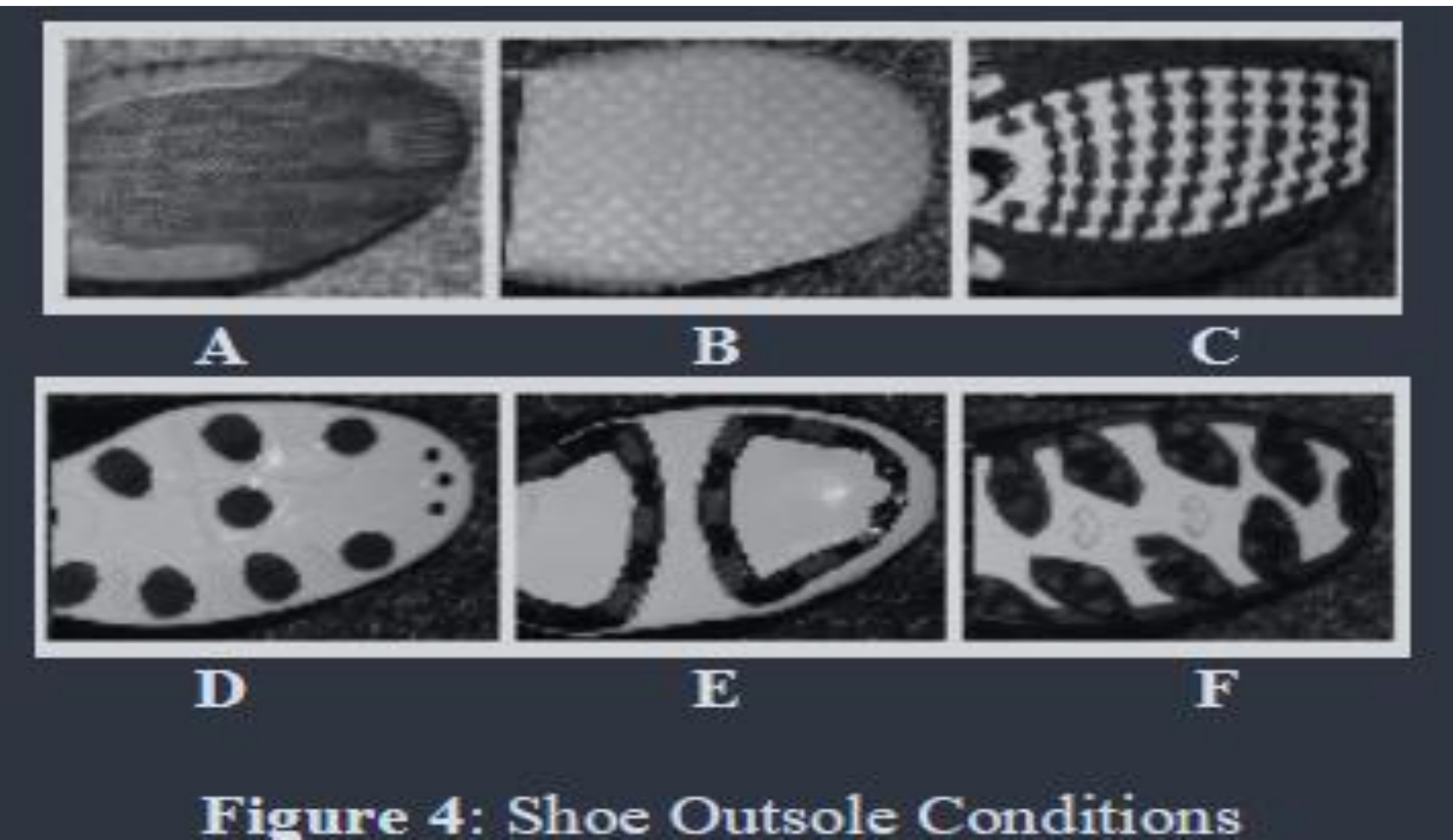


Figure 4: Shoe Outsole Conditions

Playing Surface Characteristics:

- Natural grass vs artificial turf
- Turf: more consistent
 - $\uparrow$ traction
- Grass: more give
 - $\downarrow$ joint loading
- Injury trends:
 - Turf has higher rate of soft tissue injuries (Reiad et al., 2025)
 - Higher ACL risk in some populations (Mikhail et al., 2025)

Table 1: Synthetic Surface Characteristics

Condition	AT	AP	FT
Product Name	AstroTurf	AstroPlay	Fieldturf
Underlayment	10 mm foam	-	-
Grass-Fibres	10 mm	50 mm	50 mm
Infill depth	-	40 mm	40 mm
Infill material	-	Rubber granules	Rubber granules and sand particles

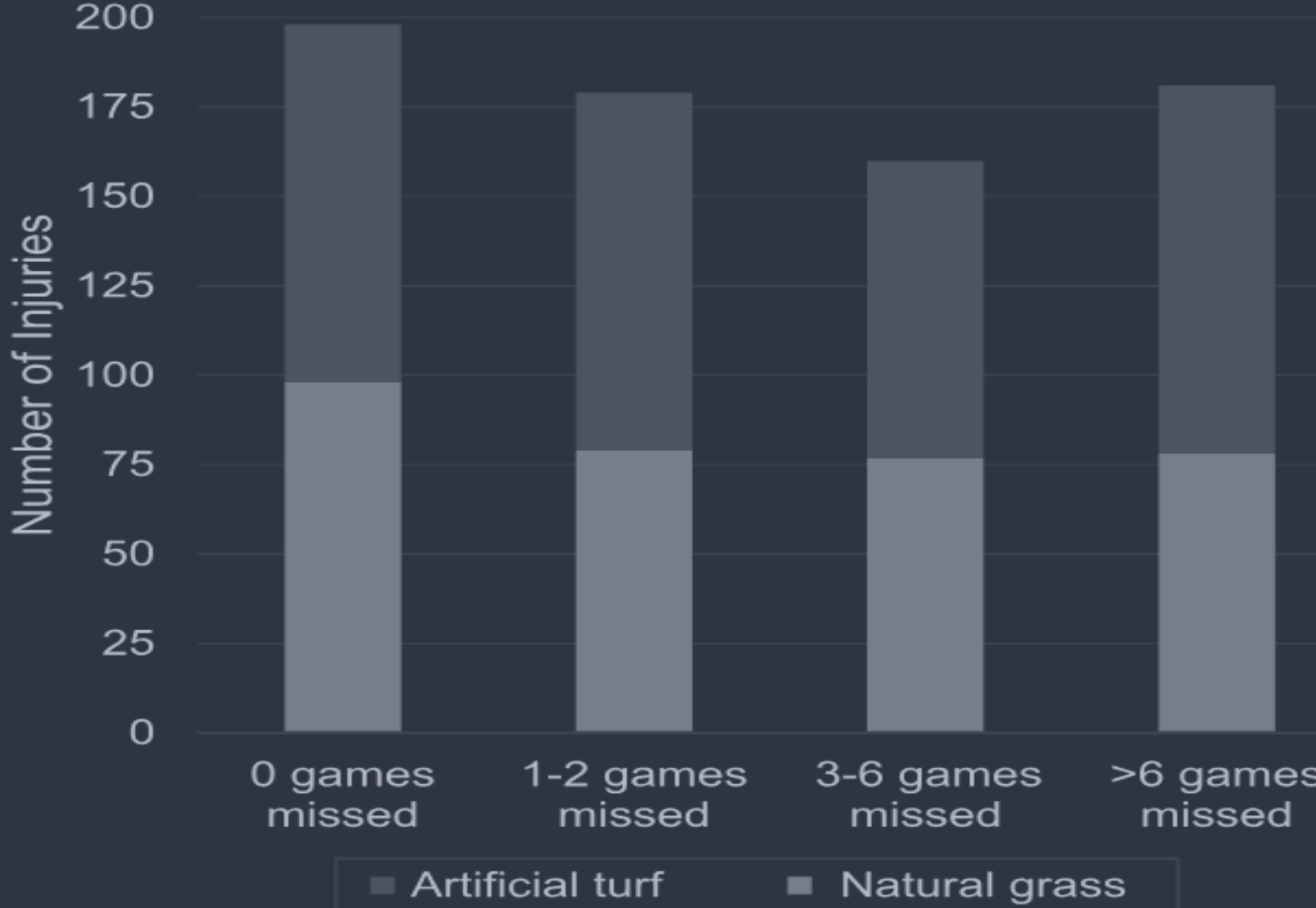


Figure 1. Injuries on artificial turf versus natural grass during the 2021 and 2022 National Football League seasons.

Methods:

- Databases: Google Scholar, PubMed
- Keywords: “shoe-surface interaction”, “traction injury risk”, “turf vs grass”, “ACL biomechanics”
- Included: biomechanics studies, injury epidemiology, review articles

Conclusion:

- Shoe-surface interaction strongly affects injury risk
- Both footwear AND surface matter
- Too much traction $\rightarrow$ $\uparrow$ injury risk
- Too little traction $\rightarrow$ $\downarrow$ performance

Future Directions:

- Identify optimal traction levels
- Study real-game environments
- Individualize footwear
- Explore insoles + non-sport footwear

Citations:

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