Football Playing Surface and Shoe Design Affect Rotational Traction

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Background: High rotational traction between football shoes and the playing surface may be a potential mechanism of injury for the lower extremity.

Hypothesis: Rotational traction at the shoe-surface interface depends on shoe design and surface type.

Study Design: Controlled laboratory study.

Methods: A mobile testing apparatus with a compliant ankle was used to apply rotations and measure the torque at the shoe-surface interface. The mechanical surrogate was used to compare 5 football cleat patterns (total of 10 shoe models) and 4 football surfaces (FieldTurf, AstroPlay, and 2 natural grass systems) on site at actual surface installations.

Results: Both artificial surfaces yielded significantly higher peak torque and rotational stiffness than the natural grass surfaces. The only cleat pattern that produced a peak torque significantly different than all others was the turf-style cleat, and it yielded the lowest torque. The model of shoe had a significant effect on rotational stiffness.

Conclusion: The infill artificial surfaces in this study exhibited greater rotational traction characteristics than natural grass. The cleat pattern did not predetermine a shoe's peak torque or rotational stiffness. A potential shoe design factor that may influence rotational stiffness is the material(s) used to construct the shoe's upper.

Clinical Relevance: The study provides data on the rotational traction of shoe-surface interfaces currently employed in football. As football shoe and surface designs continue to be updated, new evaluations of their performance must be assessed under simulated loading conditions to ensure that player performance needs are met while minimizing injury risk.

Keywords: artificial surface; rotational traction; ankle; knee; injury

Injuries to the lower extremity are among the most frequent injuries for all levels of sports and often account for more than 50% of reported injuries.[8] In the National Football League, ankle and knee sprains combine to account for about 20% of all reported injuries.[22,23] These injuries can occur during contact between players or in noncontact situations, such as a rapid change in direction or with a combination of high compressive load and twist during a jump landing.[3,7] Frequently the mechanism of injury involves a foot planted on the playing surface with an excessive internal rotation of the upper body.[11]

Traction is defined by the American Society for Testing and Materials Committee on Sports Equipment and Facilities to be the resistance to relative motion between a shoe outsole and a sports surface that does not necessarily obey classical (Coulomb) laws of friction.[1] Although linear traction is necessary for high-level performance during any athletic contest,[26] it is generally accepted that excessive rotational traction may precipitate ankle and knee injuries.[4,15,20,28] A previous study of anterior cruciate ligament (ACL) injuries in high school football players documented a significant relationship between cleat design, the amount of rotational traction, and the risk of ACL injury on grass.[15] The edge-cleat design produced significantly higher rotational traction and was associated with an ACL injury rate 3.4 times higher than that of all other designs combined.

Other studies have noted differences of injury rate in the presence or absence of specific risk factors, such as whether the surface was natural grass or an articial surface. These differences in injury rate may be due to variations in the structure and materials of the turf,[12] the running speed of the players,[27] or the coefficient of friction between the surface and shoe.[2] The injury risk factor may also depend on

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the player's position and the type of play at the time of injury, both of which would influence loading mechanisms on the lower extremity.

Although rotational traction has been documented in previous studies (usually as the peak torque magnitude recorded during dynamic testing) for numerous shoe-surface interfaces, most testing devices are not portable and therefore cannot be used to test the actual playing surfaces.[4,5,15,28] The aforementioned studies also have not evaluated the types of synthetic surfaces currently used in professional, college, and high school football. The modern synthetic surface is a sharp contrast to the dense and abrasive turfs that were introduced in the 1970s. Artificial surfaces now consist of longer, more grass-like fibers that are surrounded and stabilized by infill materials, such as rubber and sand. A more recent study measured the peak torque and rotational stiffness developed at the shoe-surface interface of 3 infill systems with a portable testing device.[16] The limitations of that study were the small compressive normal force and the use of only the forefoot cleats rigidly mounted on a plate. Rotational stiffness (defined as the slope of the torque versus rotation data in a predefined angular range) was identified as a more sensitive indicator of the mechanical interaction between different shoe-surface combinations than the peak torque.[16]

Limited data are available with regard to the rotational traction of cleated football shoes on modern synthetic infill surfaces. The purpose of the present study was to investigate the rotational shoe-surface interactions using a variety of shoes and surfaces currently employed in football by means of a mobile testing apparatus constructed with a surrogate lower leg. The first hypothesis of the study was that shoe designs with numerous and/or large cleats around the peripheral margin of the sole would exhibit higher rotational traction than shoes with fewer or smaller cleats on the peripheral margins. The second hypothesis was that manufacturer and material variation between shoe models would result in rotational traction differences among shoe models within cleat pattern groups. The third hypothesis was that an artificial surface that allows greater infill contact with the cleat will produce higher rotational traction than natural grass and similar artificial surfaces that limit infill contact with the cleat. A better understanding of the interaction between current shoe-surface interfaces will provide athletic teams with information on the rotational traction of various shoe-surface combinations. These data may ultimately have relevance to the risk potential for rotational lower leg injuries on various shoe-surface interface combinations.

MATERIALS AND METHODS

Four different surfaces were evaluated in this study: (1) an artificial surface with an infill composed of a sand/rubber blend (FieldTurf, FieldTurf Tarkett, Montreal, Quebec, Canada), (2) an artificial surface with a 100% rubber infill (AstroPlay, Southwest Recreational Industries, Inc, Leander, Texas), (3) natural grass composed of Kentucky bluegrass and a small percentage of ryegrass in combination with a native Michigan soil, and (4) natural grass composed of Kentucky bluegrass and a small percentage of ryegrass in combination with a custom soil engineered for strength and drainage that consisted of 90% sand and 10% silt and clay. The FieldTurf system was the playing surface used in an indoor sports complex, and it was installed 7 years before testing. The AstroPlay system was the playing surface used in another indoor sports complex, and it was installed 5 years before testing. Both natural grass plots were part of outdoor football fields with full-time maintenance staff.

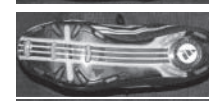
The FieldTurf was composed of parallel slit polyethylene fibers with an approximate 50/50 combination of layered silica sand and cryogenically processed crumb styrene-butadiene rubber infill,[9] with a primary top layer of cryogenic rubber. The fiber layout of FieldTurf is constructed with a gauge length of 3/4 in. This measurement refers to the distance between rows of fiber tufts. The AstroPlay was composed of parallel slit polyethylene fibers constructed with a 3/8-in gauge length and with an all-cryogenically processed styrene-butadiene rubber crumb infill.

Each surface was tested using 10 different shoes (Table 1), yielding 40 different shoe-surface combinations. The shoes were grouped into 5 categories based on design properties: (1) cleated shoes with 7 removable cleats, 5 covering the forefoot of the sole and 2 covering the heel region (7-studded); (2) molded cleat shoes with 12 cleats around the perimeter of the sole, 8 around the forefoot, and 4 around the heel region (12-studded); (3) molded-cleat shoes with 4 cleats around the heel region and at least 15 cleats distributed across the forefoot region (hybrid); (4) cleat designs characterized by blade-style cleats (edge); and (5) shoes with a dense pattern of short elastomeric cleats distributed over the entire sole (turf).

Because of the mechanical interpenetration of the cleats and playing surface, as well as properties of the materials themselves, rotational traction depends on many factors that require the measurements be made at loads and rates of loading that are expected to occur in vivo.[1] A testing apparatus was developed to simulate the anthropomorphic data of a 95th percentile male.[24] This included matching the compressive load to $1 \times$ body weight (1000 N) and fabricating the surrogate lower leg with a tibia length of 44 cm.[24] In addition to reproducing key mass and length measurements for the surrogate leg, the ankle was designed to be compliant with regard to internal/external rotation by means of a deformable elastomeric washer at this location.

The testing apparatus (Figure 1) was designed to apply a dynamic rotation and measure the torque produced at the shoe-surface interface. The apparatus was fabricated to conform to an international standard method for measuring rotational traction characteristics of an athletic shoe-surface interface.[1] The device consisted of an aluminum frame that could be raised and lowered to the ground with wheels to allow for easy mobility. The frame supported the surrogate lower limb, a suspended 425-N weight, and a 0.25-m radius gear, which were used to produce a torque on the shoe. The weights were released by means of a manual lever arm located on the side of the testing device. The drop height of the weight hanger was adjusted so that the input rotation angle of the shaft was 90°. The rate of rotation was approximately 180 deg/s, which exceeds the minimum of 45 deg/s required by the

TABLE 1
Cleat Descriptions

Category	Manufacturer	Model	Height	Cleat Material[a]	Number of Cleats	Maximum Cleat Length (mm)	Image
12-studded peripheral molded cleats	Nike	Blade II TD	Mid-cut	Elastomeric	14	16.3	
	Adidas	Scorch 7 Fly	Low-cut	TPU	13	12.5	
Edge (molded blades)	Nike	Vapor Jet TD	Low-cut	TPU	12	12.0	
	Adidas	Scorch TRX	Low-cut	TPU	15	13.0	
	Adidas	Corner Blitz 7 MD	Mid-cut	Elastomeric	15	11.0	
Hybrid (15+ molded cleats	Nike	Air Zoom Superbad FT	Mid-cut	Elastomeric	21	11.0	
	Adidas	Grid Iron	Mid-cut	Elastomeric	20	12.0	
7-studded replaceable cleats	Nike	Air Zoom Blade D	Mid-cut	TPU (steel tip)	7	12.5	
	Adidas	Quickslant D	Mid-cut	TPU (steel tip)	7	12.5	
Turf (molded nubs)	Adidas	Turf Hog LE	Mid-cut	Elastomeric	88	6.5	

[a]TPU, thermoplastic polyurethane.

American Society for Testing and Materials testing standard.[1] The frame was stabilized on the test surfaces by 2 operators standing on outboard platforms.

To better represent a worst-case injury situation, the current study replicated a loading condition having full cleat contact with the ground. The peak torque measured in tests with full cleat contact has been shown to be typically 70% higher than tests with only forefoot cleats.[4] A rigid model of the right foot was fabricated and attached below the ankle position on the testing device. The foot represented a US size 13 shoe and the center of rotation on the test device was adjustable. For all tests documented in this report, the center of rotation was set at the midfoot, a distance of 14 cm from the heel.

The device generated a dynamic internal rotation of the leg, resulting in an externally directed ground reactionary torque on the foot. A torsional load cell (Model 1261, Interface, Scottsdale, Arizona) was placed below the gear and connected to the lower leg shaft to record torque. In addition, 2 angular displacement transducers (Model 0605-S7104010201, Trans-Tek Inc, Ellington, Connecticut) were used to record the rotation of the lower limb segments. The first transducer measured total rotation of the leg and was located above the compressive weights. The second was placed inside the artificial leg to measure the relative rotation at the ankle (between the foot and shaft). The difference between leg and ankle rotation provided the shoe rotation relative to the ground.

The data were processed through a strain-gauge amplifier (Model 3B18-00, Analog Devices, Inc, Norwood, Massachusetts) connected to an A2D card (Model PC-Card-DAS16/16, Measurement Computing Corp, Norton, Massachusetts) and recorded on a laptop computer (N Series Lifebook, Fujitsu, Tokyo, Japan). A custom program was written in LabView (Version 7.0, National Instruments, Austin, Texas) for data collection. Data were collected for 5 seconds at 1000 Hz and the recorded data from each trial consisted of 100 milliseconds before and 900 milliseconds after a torque threshold of 3 N·m was reached in the test. Five trials were performed for each shoe-surface combination. The testing apparatus was

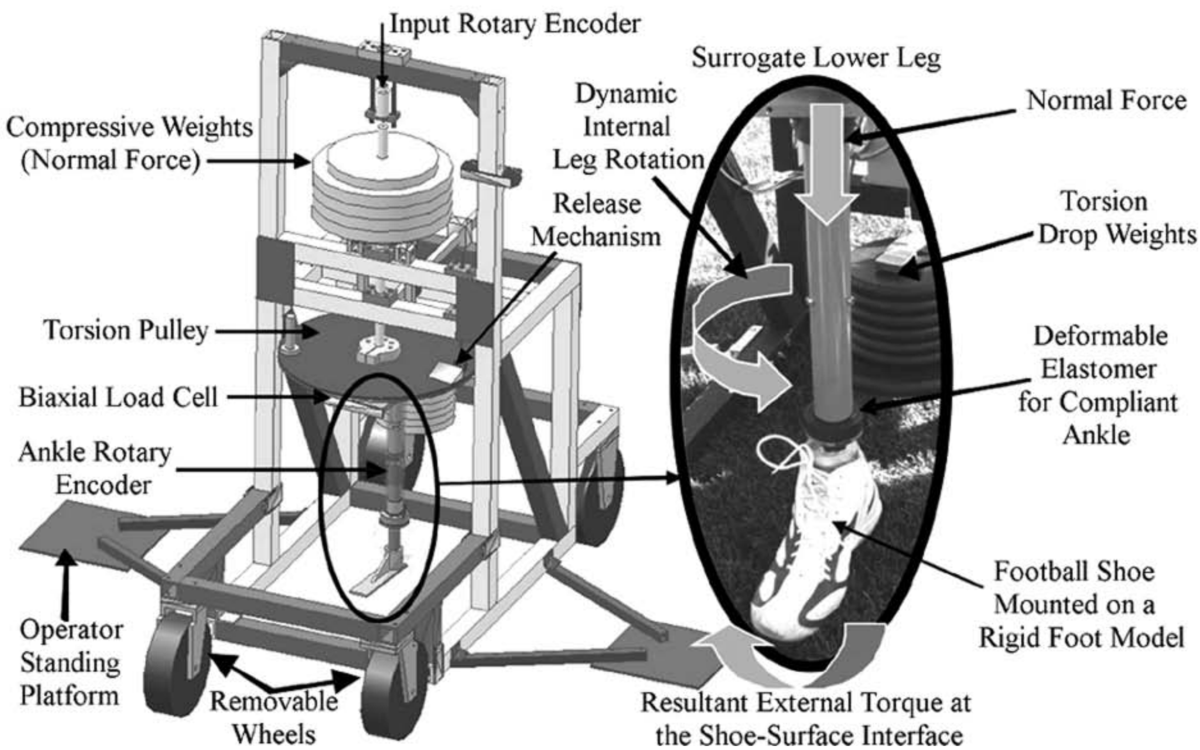


Figure 1. Testing apparatus.

repositioned between trials to a new adjacent section of turf. The air temperature was also recorded for each day of testing.

Data from all trials were analyzed to determine the peak torque. Plots were created to document the change in torque relative to the degree of shoe rotation allowing for the calculation of rotational stiffness. In the current study, we found that the shoe upper could flex under the applied torque and rotate about the midfoot axis as the edge of the shoe plowed through the surface. Therefore, a calculation of rotational stiffness between fixed angles, as used by Livesay et al,[16] was not advisable. It was necessary to compute the stiffness between 2 predetermined levels of torque for all shoe-surface interfaces. The chosen interval was from the start of the test, identified by 3 N·m of torque, to 75% of the peak torque generated for each particular test.

The average peak torque and rotational stiffness of the 5 trials were used for subsequent statistical analyses. A 2-way analysis of variance, surface (n = 4) by shoe model (n = 10), was conducted in SigmaStat (Version 2.03, SPSS Inc, Chicago, Illinois) to assess the effect of surface and shoe on the peak torque and rotational stiffness. Tukey post hoc tests were performed when indicated. The effect of cleat pattern (n = 5) was assessed by a 1-way analysis of variance with Tukey post hoc tests, when appropriate. Statistical significance was set at $P < .05$ in all analyses.

RESULTS

Torque and rotational data were collected on each of the 40 shoe-surface combinations. The shoe was tested with full cleat contact on the ground and a compressive load of 1000 N. The plots of torque versus relative rotation of the shoe were analyzed (Figure 2), and several distinct regions were noted: (1) the initial breakaway region, typified by the buildup of torque to begin rotation; (2) a period of increasing torque as the shoe continued to rotate; (3) a period of relatively constant torque attributed to slippage between the shoe and surface; and (4) a period of unloading at the end of the test. The typical plot consisted of all 4 regions (Figure 2A). If the leading edge of a shoe was twisted and appeared to plow into the surface, as was the case with shoes with relatively pliable uppers (7 Fly, Superbad, TRX, and Vapor), often only 3 regions were noted by the omission of a distinct slippage region (Figure 2B).

All natural grass testing was conducted in Michigan in early autumn at approximately the midseason of football. No testing was performed if excessive moisture or a previous rain was noted. The air temperature when testing the surfaces varied during this series of experiments (Table 2).

Cleat Pattern

The classification of shoe groups did not yield any relationships between cleat pattern and rotational stiffness (Table 3). Significant differences in peak torque were only noted with comparison to the turf cleat (Table 4). The turf cleat produced significantly lower torque than all other groups ($P < .001$). There were no significant differences between the 12-studded, edge, hybrid, and 7-studded cleat pattern groups.

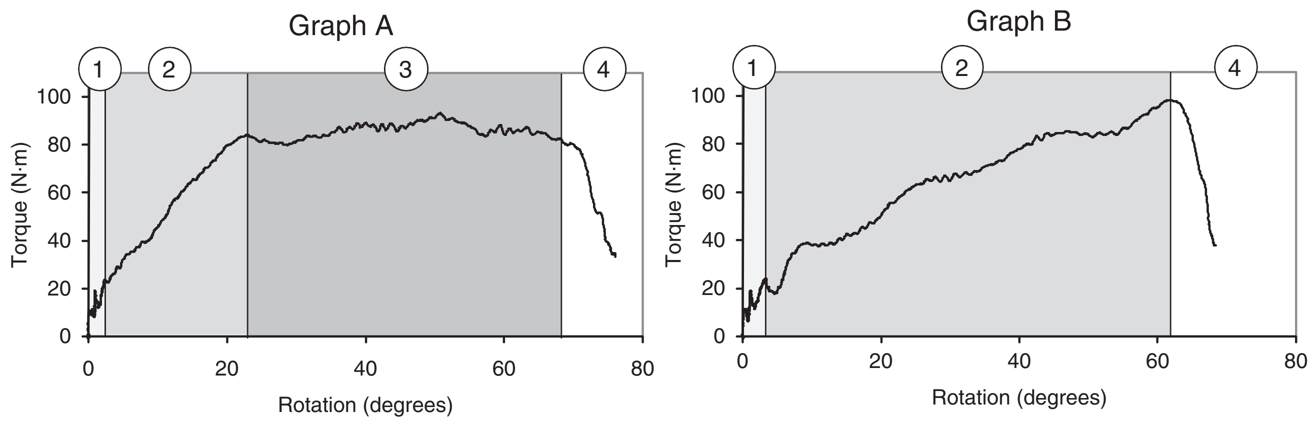


Figure 2. Representative shapes of the torque versus shoe rotation data. A, 4-region plot (initial breakaway, buildup, slippage, unloading); B, 3-region plot (omission of slippage). The percentage of rotation that occurred in each region was dependent on the shoe-surface combination and varied between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

Shoe Model

With the exception of the Adidas Turf Hog, the model of shoe was not found to have a significant effect on the peak torque (Table 4). The model of shoe did significantly affect rotational stiffness (Tables 3 and 5). The Adidas Blitz produced significantly higher rotational stiffness than 6 other models. This was likely attributable to its large rubber cleats and, perhaps more importantly, relatively rigid upper and sole. By comparison, the shoe that produced a rotational stiffness significantly lower than 5 other models, the Nike Superbad, had a relatively pliable upper sole, making it more capable of rotating on the rigid footform. This allowed the medial edge of the shoe to dig into the ground and continually add rotational traction after breakaway (the initial release of the shoe from the surface).

Surface

The values of peak torque and rotational stiffness were significantly affected by the playing surface (Tables 3 and 4). Both artificial surfaces produced higher torques ($P <$ .001) than natural grass surfaces. The natural grass surface with engineered, sand-based soil produced higher torques ($P = .008$) than natural grass with native Michigan soil. The rotational stiffness for both artifical surfaces was higher ($P < .001$) than each of the natural grass surfaces. The stiffness of the different systems of artificial or natural grasses was not statistically different from one another.

TABLE 2
Temperature at Time of Testing by Surface Type

Surface	Air Temperature (°C)
FieldTurf	21
AstroPlay	21
Grass, sand-based	11
Grass, native soil	32

DISCUSSION

High rotational traction between football shoes and playing surfaces may yield a potential for injury to the lower extremity.[4,15,20,28] The current study used a mobile apparatus to record the torque and relative rotation at the shoe-surface interface for a variety of currently available, cleated football shoes in combination with synthetic infill surface systems and natural grasses. A wide variation in peak torques between shoe-surface interfaces was not unexpected, based on the current literature. A previous study by Cawley et al[5] shows a torque range of 50 to 120 N·m for 7-studded and turf shoe designs on grass. The trend in peak torque across surfaces was also noted to be similar to a previous study by Livesay et al[16] that examined several infill surfaces using a lower compressive load and forefoot cleats rigidly mounted to a circular plate. Although those results could not be directly related to the current data, in both studies the grass surfaces produced the lowest peak torques.

The classification of shoe groups based on cleat pattern did not predetermine a shoe's rotational traction characteristics. The only cleat pattern designation that produced peak torques significantly different than all other groups was the turf-style cleat. The short elastomeric cleats may not have penetrated the infill layer or soil as deeply as the other models to help limit the degree of rotational traction. The wide range of torques noted both within and across shoe groups emphasized the effect of other factors, beyond cleat pattern, that may affect rotational traction. Therefore, the first hypothesis that related rotational traction to cleat pattern could not be validated in the current study. The second hypothesis, which related rotational traction to shoe model, was validated with regard to rotational stiffness. The shoe shape, upper material, and construction

TABLE 3
Rotational Stiffness (N·m/deg)[a]

	Cleated Shoe											
	12-Studded		Edge			Hybrid		7-Studded		Turf		
Surface	Blade II	7 Fly	Vapor	TRX	Blitz	Superbad	Grid Iron	Blade D	Quickslant	Turf Hog	Mean Across Surfaces	SD
FieldTurf	4.0	3.7	4.0	3.0	5.1	2.5	4.2	3.1	3.4	3.1	3.6[b]	1.5
AstroPlay	3.2	3.8	3.6	3.2	4.3	2.4	4.3	3.4	3.3	3.4	3.5[b]	1.3
Grass, sand-based	2.2	2.0	2.3	2.0	2.5	1.7	2.5	2.9	2.7	1.6	2.2	0.8
Grass, native soil	1.7	2.0	2.0	2.3	3.2	1.4	2.4	2.3	2.5	2.2	2.2	0.9
Mean across shoes	2.8	2.9	3.0	2.6	3.8	2.0	3.3	2.9	3.0	2.6		
SD	1.0	0.9	0.9	0.5	1.1	0.5	1.0	0.6	0.6	0.8		

[a]SD, standard deviation.
[b]Significant difference from natural grass surfaces ($P < .001$).

TABLE 4
Peak Torque (N·m)[a]

	Cleated Shoe											
	12-Studded		Edge			Hybrid		7-Studded		Turf		
Surface	Blade II	7 Fly	Vapor	TRX	Blitz	Superbad	Grid Iron	Blade D	Quickslant	Turf Hog	Mean Across Surfaces	SD
FieldTurf	135.8	120.4	131.6	129.0	121.8	117.4	112.4	119.6	113.4	81.4	118.3[b]	15.2
AstroPlay	121.6	107.8	118.4	117.0	109.2	119.8	109.6	130.8	105.8	78.4	111.8[b]	14.5
Grass, sand-based	115.6	107.4	100.4	98.6	74.2	101.4	84.8	112.4	104.6	59.6	95.9[c]	18.0
Grass, native soil	87.6	95.0	98.6	79.8	77.8	73.6	81.4	83.0	94.4	60.0	83.1[c]	12.3
Mean across shoes	115.2	107.7	112.3	106.1	95.8	103.1	97.1	111.5	104.6	69.9[d]		
SD	19.3	10.9	14.9	20.1	21.2	19.4	15.3	19.4	8.8	11.0		

[a]SD, standard deviation.
[b]Significant difference from natural grass surfaces ($P < .001$).
[c]Significant difference from all other surfaces ($P = .008$).
[d]Significant difference from all other shoe models ($P < .001$).

TABLE 5
Rotational Stiffness Post Hoc Comparison Between Shoe Models[a]

	Blade II	7 Fly	Vapor	TRX	Blitz	Superbad	Grid Iron	Blade D	Quickslant	TurfHog
Blade II	-	1.000	.997	1.000	***.012***	.149	.471	1.000	.997	.999
7 Fly	1.000	-	1.000	.988	***.031***	.064	.728	1.000	1.000	.974
Vapor	.997	1.000	-	.900	.081	***0.024***	.923	1.000	1.000	.849
TRX	1.000	.988	.900	-	***.003***	.417	.177	.963	.903	1.000
Blitz	***.012***	***0.031***	.081	***.003***	-	***<.001***	.705	***.049***	.079	***.002***
Superbad	.149	.064	***.024***	.417	***<.001***	-	***<.001***	***.041***	***.025***	.493
Grid Iron	.471	.728	.923	.177	.705	***<.001***	-	.832	.921	.139
Blade D	1.000	1.000	1.000	.963	***.049***	***.041***	.832	-	1.000	.934
Quickslant	.997	1.000	1.000	.903	.079	***.025***	.921	1.000	-	.853
Turf Hog	.999	.974	.849	1.000	***.002***	.493	.139	.934	.853	-

[a]Significant differences are shown in **boldface**.

may all be possible contributors to the varying amounts of rotational stiffness.

One potential limitation of the present study was the surrogate ankle. The deformable elastomer used to represent the torsional stiffness of the ankle joint averaged 11 N·m/deg, exceeding in vivo measurements of 1.2 N·m/deg by Mote and Lee.[19] However, the in vivo stiffness recorded in the previous study was limited to amplitudes of ±6°, a significant limitation in the overall response of the joint. Assuming the in vivo stiffness of the ankle joint can be modeled by a bilinear response similar to the knee joint,[6] the secondary stiffness of the ankle may be on the order of 3 to 5 times the primary stiffness, yielding a maximum torsional stiffness of 6 N·m/deg for the ankle. The surrogate ankle may also be improved by the incorporation of additional degrees of freedom that may alter loading mechanisms on a surface. Inversion/eversion of the ankle may increase the medial edge loading mechanism and dorsiflexion/plantar flexion may affect the load distribution across the cleats. Incorporation of these designs into a surrogate ankle may help to generate more physiologic responses of the lower leg at the shoe-surface interface.

The artificial surfaces were tested at similar temperatures, while the air temperature for the natural grass testing varied by 21°C. A previous study showed that an increase in air and turf temperature did have an effect on the shoe-surface traction for an artifical surface.[29] In an extensive literature search, no evidence was gathered regarding a relationship between the ambient air temperature and its effect on traction for a natural grass system. The effect of climate on natural grass systems has been considered in epidemiologic studies involving the frequency of injury and the time of season.[21] In a rugby study, it was concluded that there was a bias toward a higher frequency of injury in the summer months that was proportionately greater for backs, the players who tend to sustain more noncontact injuries.[10] A major contributor to this bias was believed to be ground hardness, brought about by drier and warmer conditions in the summer season. Both natural grass systems in the present study were tested in the same autumn month, and they were regularly watered.

A potential threshold for a “safe” torsional release coefficient of shoes and surfaces was introduced in the 1970s.[28] In the current study, a normal force of 1000 N would generate a theoretical safe torque of approximately 95 N·m, based on the previous study results. Most shoe-surface interface values in the current study exceeded this threshold level. This level also exceeds the maximum torque that the ankle can support, approximately 75 N·m, based on cadaver tests.[13] On the other hand, Shoemaker et al[25] suggest that muscles may contribute as much as 70 N·m of resistive torque and help protect the lower extremity from injury during controlled athletic maneuvers.

It is unknown if differences in rotational stiffness at the shoe-surface interface might affect the risk of injury, as suggested in the Livesay et al[16] study. The lower rotational stiffness observed for both natural grass systems compared with the artificial surfaces indicated a lower rate of loading. This might allow more time for a protective type of neuromuscular control in the lower extremity that could help stabilize the ankle and knee joints during cutting maneuvers.[16] The differences in rotational stiffness across shoes may also influence injury risk. A potential design factor may be the materials used to construct the shoe’s upper. A shoe with a pliable upper may allow more time for neuromuscular control, but it may also allow the foot to pronate while the leg is internally rotated. This loading scenario may result in rupture of the anterior tibiofibular ligament, a severe time loss injury.[11] Future epidemiologic studies of shoe and surface injury rates on infill-based surfaces and grass will be important in generating the “real” injury risk for various shoe-surface interfaces.

In conclusion, an extensive amount of work exists concerning the interaction of football cleats with the older generation of non-infill artificial surfaces, yet much remains unknown about the performance characteristics of modern infill artificial surfaces. The present study investigated the dynamic performance of a number of currently used football shoes and cleat designs on natural grass and infill-based artificial surfaces under a compressive load that may be representative of a 95th percentile male during a sports activity. It is important to continue to gain an understanding of the tractional characteristics of the shoe-surface interface as manufacturers continue to update cleat and surface designs. To meet the critical need of improving the design of shoe-surface interfaces, many areas still need further research. The effects of moisture and temperature on traction characteristics of infill-based artificial surfaces need additional study. It is also unknown whether an internally directed ground-reaction torque would engage the cleats in a different manner and generate different torque results. Meyer et al[17] demonstrated that this type of loading may generate isolated rupture of the ACL. From a performance aspect, linear traction testing would assess a player’s need for speed and agility.[14,18] These data could then be used to help improve shoe-surface interfaces and mitigate injury potential while maintaining player performance.

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