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Turf-toe: An analysis of metatarsophalangeal joint sprains in professional football players

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ABSTRACT

Metatarsophalangeal joint injuries of the great toe (turf-toe) are receiving increasing attention in the literature because of the prevalence of synthetic surfaces and lighter, more flexible shoes. Eighty active professional football players were evaluated. The mechanism of injury was hyperextension in 85% of the players. Eighty-three percent reported their initial injury on artificial turf ($P < 0.05$). Other factors significantly related to the incidence of turf-toe included player age ($P < 0.01$), number of years in professional football ($P < 0.01$), and range of ankle dorsiflexion ($P < 0.05$). Turf-toe injury resulted in significantly decreased range of motion of the first metatarsophalangeal joint ($P < 0.01$).

Acute injuries of the first metatarsophalangeal joint in football players have become a significant concern of athletes, coaches, team physicians, and trainers. Such a plantar capsule ligament sprain in commonly known as "turf-toe."[1] Despite the increasing incidence of these injuries and the considerable disability associated with both acute and chronic injuries, this injury has received little attention in the literature.

Several previous studies have reported on the incidence of turf-toe among college football players. At West Virginia University there were 27 reported cases of turf-toe among a population of 500 players from the beginning of the 1970 season through the 1974 season, an average of 5.4 cases per year.[1] The University of Arkansas football players sustained 18 cases of turf-toe from 1972 to 1974, an average of 6.0 cases per year.[4] Although there was an average of 24.7 ankle sprains per year during this same period at the University of Arkansas, turf-toe injuries accounted for seven missed games, while ankle sprains accounted for only six missed games. A retrospective survey of Rice University football players from 1971 to 1985 revealed an average of 3.8 cases per year.[3] All of these teams played on an artificial surface.

The advent of artificial surfaces and lighter, more flexible shoes for use on artificial turf are suspected causes for the increasing incidence of turf-toe.[4] Although this injury is most commonly seen among football players, it has been reported among soccer and basketball players as well.[5,8] The present study is the first to explore the incidence of turf-toe among professional football players. The purpose of this study is to identify risk factors for turf-toe, examine mechanisms of injury, and analyze the effect of turf-toe injury on foot and ankle motion. Other factors related to the development of turf-toe are also discussed, including shoe type and playing surface.

MATERIALS AND METHODS

Eighty active professional football players representing two teams were evaluated. The age range of these players was 21 to 34 years. One of the teams played on artificial turf on their home field (45 players), and the other team had natural grass on their home field (35 players).

A detailed questionnaire was completed for each player. This questionnaire assessed player position, mechanism of injury, playing surface and shoe type when injured, treatment received, and playing time missed (Fig. 1). Each player also underwent physical examination of the foot and ankle using a standard measuring technique blind to the players' injury status. The physical examination assessed range of

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TURF-TOE ASSESSMENT

To be completed by team physician, trainer, or medical personnel The following questionnaire is designed to assess the syndrome of 'turf-toe' (metatarsophalangeal joint sprain of the great toe) This information will be used to monitor the prevalence of this injury among football players, create a profile of players with this injury, and assess treatment procedures Please provide the required information as accurately and thoroughly as possible. All player information will remain confidential

PLEASE FILL IN OR CIRCLE APPROPRIATE RESPONSE

1) Player Name _____ Position _____
2) College _____ # Years in College _____
3) NFL Team _____ # Years in Pros _____
4) Onset of Injury College_____ Pro_____
5) Left / Right / Bilateral
6) Acute / Chronic
Duration of Symptoms. Days / Weeks / Months
7) Dates of Injury and Recurrences:
College _____
Pro _____
8) Surface. Artificial / Grass / Dirt
9) Treatment, and Player Satisfaction with Treatment:
(E=Excellent S=Satisfactory P=Poor)
Medication (Specify): _____ E/S/P
Surgery (Location and date): _____ E/S/P
Orthotic (Type) _____ E/S/P
Taping Procedures _____ E/S/P
X-Ray Taken _____
10) Number games missed College _____ Pro _____
11) Amount practice time missed. College _____ Pro _____
12) Mechanism of Injury:
__Hit from behind, toe in dorsi-flexion, heel off of ground --> Hyper-extension injury
__Ankle and toe in plantar flexion
Other (Describe): _____
_____
13) Pes planas ____
14) Pes cavus ____
15) Hallux rigidus ____
16) Hallux valgus ____
17) Hallux varus ____
19) Length of second toe compared to great toe < = >
20) Range of motion.

	Ankle (Measured with foot at 90)	Great toe (foot at 90)
Right	Extension_____	Extension_____
	Flexion_____	Flexion_____
Left	Extension_____	Extension_____
	Flexion_____	Flexion_____

21) Chronic swelling Yes_____ No_____
22) Crepitation ____
23) Associated fractures None ____
Phalanx Distal ____ Proximal ____
Metatarsal ____ Cuboid_____ Navicular_____
Cuneiform (specify #) _____ Sesamoid_____
Specify other associated foot problems or pathology _____
_____
24) Capsular tear: ____
25) Chondromalacia of head of first metatarsal ____
26) Shoe type Conventional football shoe (seven post) ____
Soccer style (twenty cleat) ____
Brand _____
27) Age of shoe _____
28) Player's Weight. _____
29) Player's Age. _____
30) Any further comments or relevant information

YOUR CONTRIBUTION IS APPRECIATED. RESULTS WILL BE MADE AVAILABLE TO ALL TEAMS.

Figure 1. Turf-toe questionnaire assessed player position, mechanism of injury, playing surface, and shoe type when injured, treatment received, and playing time missed. The physical examination of players with turf-toe included measurement of range of motion at the ankle and first metatarsophalangeal joint, assessment of pes planus or pes cavus foot configuration, hallux varus or hallux valgus, and length of the second toe compared to the great toe.

motion at the first metatarsophalangeal joint and ankle, pes planus or pes cavus foot configuration, hallux valgus and hallux varus, and length of the second toe compared to the great toe (Fig. 1). Selected players with symptomatic turf-toe underwent radiographic evaluation.

Several player characteristics and anatomical factors were explored to determine risk factors for turf-toe injury. This study also examined the effect of turf-toe injury on the function of the first metatarsophalangeal joint and ankle. Statistical analysis was performed using Student's t-test and chi-square analysis. The Apple Macintosh Statview 512 statistical program was used. Factors were considered significant at $P < 0.05$.

RESULTS

Forty-five percent ($N = 36$) of players surveyed had incurred turf-toe. There was no significant difference between percentage of injured players on the artificial turf team compared to the percentage of players on the natural grass team. Forty-six percent ($N = 21$) of the players from the team with artificial turf on their home field reported turf-toe injury, compared to 43% ($N = 15$) of players from the team with natural grass on their home field. However, among those players in which the type of playing surface upon which they incurred their initial injury could be determined ($N = 29$), 83% ($N = 24$) report initial injury on an artificial surface ($P < 0.01$).

The mechanism of injury was determined in 72% ($N = 26$) of the injured players. Eighty-five percent ($N = 22$) of injured players suffered a hyperextension injury of the first metatarsophalangeal joint. Twelve percent of injured players ($N = 3$) sustained a plantar flexion injury to the first metatarsophalangeal joint, and in 4% ($N = 1$) the mechanism of injury was a valgus stress.

Examination of the relationship between player position and incidence of turf-toe revealed that running backs, offensive linemen, tight ends, and wide receivers had a higher incidence of turf-toe injury. Sixty percent of offensive players surveyed had incurred turf-toe, compared to 32% of defensive players. However, these values were not statistically significant. Table 1 contains a summary of playing position for injured players and controls.

TABLE 1
Playing position of injured and uninjured players

	Grass homefield ($N = 15$)	Turf homefield ($N = 21$)	All injured ($N = 36$)	Control ($N = 44$)
Offense				
Tight end, wide receiver	1	7	8	6
Running back, quarterback	5	4	9	5
Offensive line	3	5	8	6
Total offense	9	16	25	17
Defense				
Defensive line	1	1	2	7
Defensive back	5	3	8	8
Linebacker	0	1	1	8
Total defense	6	5	11	23
Specialty teams				
Kicker & punter	0	0	0	4

Player age and number of years in professional football were significantly related to the incidence of turf-toe. The mean number of years as a professional football player was 5.2 years for injured players versus 3.0 years for controls ($P < 0.01$). The range was 1 to 12 years for injured players and 1 to 8 years for controls. The mean age of injured players was 27.4 years versus 24.7 years for controls ($P < 0.01$). The range was 21 to 34 years of age among injured players and 21 to 30 years of age among controls. Player height, weight, and height to weight ratio were not related to the incidence of turf-toe.

Range of motion at the first metatarsophalangeal joint and ankle were compared between the injured players' uninjured side and controls to determine if differences in preinjury range of motion predispose to turf-toe. Range of motion of the injured players' uninjured side was assumed to represent preinjury range of motion of the injured extremity since there was no significant difference between left and right sides in controls. Ankle dorsiflexion was significantly related to the incidence of turf-toe. Mean ankle dorsiflexion of the uninjured side in injured players was 13.33° compared to 7.87° in uninjured players ($P < 0.05$). There were no differences between injured and uninjured players in ankle plantar flexion, first metatarsophalangeal joint dorsiflexion, or first metatarsophalangeal joint plantar flexion (Table 2).

There was a higher incidence of pes planus foot configuration (pronated foot) among players with turf-toe injury. However, this did not reach statistical significance. In addition, the following factors were not significantly related to the incidence of turf-toe: pes cavus, hallux varus, hallux valgus, and length of the second toe in relation to the great toe (Table 3).

TABLE 2
Range of motion of the first metatarsophalangeal (MTP) joint and ankle in injured and uninjured players ($N = 72$)

	Injured player (Normal side)	Uninjured player
Ankle dorsiflexion[a]	13.33	7.87
Ankle plantar flexion	36.67	37.65
First MTP dorsiflexion	48.95	53.27
First MTP plantar flexion	30.79	25.27

[a] Significantly related to incidence of turf-toe, $P < 0.05$.

The type of playing shoe worn at the time of injury was determined in 81% ($N = 29$) of injured players and 80% ($N = 35$) of controls (Table 4). There was no significant difference in shoe type among injured and uninjured players. The majority of players wear the multicleat, rubber-sole turf shoe. Forty-seven percent (23) of players wearing the rubber-sole turf shoe had incurred turf-toe injury, compared to 53% (26) of players who play in the rubber-sole shoe and were not injured. Forty percent ($N = 6$) of those players wearing the conventional rigid-sole, seven-cleat football shoe had incurred turf-toe injury, compared to 60% ($N = 9$) of players who wore the conventional rigid-sole shoe and were not injured.

TABLE 3
Foot and toe mechanics in injured and uninjured players ($N = 66$)

	Injured	Uninjured
Pes planus	22	8
Pes cavus	3	2
Hallux valgus	11	8
Hallux varus	2	0
Length of second toe compared to great toe		
2nd toe > great toe	11	10
2nd toe = great toe	12	20
2nd toe < great toe	13	14

TABLE 4
Brand names of playing shoes worn in study

Shoe type[a]	Injured ($N = 29$)	Control ($N = 35$)
Conventional seven-cleat	6	9
Multi-cleat, nibber sale		
Adidas	9	14
Converse	6	6
Nike	4	4
Pony	2	0
Kangaroo	1	0
Unspecified	1	2

[a] Adidas, Warren, NJ; Converse, North Reading, MA; Nike, Beaverton, OR; Pony, Rutherford, NJ; Kangaroo, Chesterfield, MO.

Range of motion measurements were analyzed for plantar flexion and dorsiflexion of the first metatarsophalangeal joint and ankle in players with turf-toe injury to determine if there are changes in range of motion subsequent to injury. There was a significantly decreased range of motion for both plantar flexion and dorsiflexion in the injured first metatarsophalangeal joint compared to the uninjured side in players with turf-toe. Average plantar flexion measurements in the injured and uninjured sides were 22.11° and 30.79°, respectively ($P < 0.01$). For dorsiflexion, the average values for the injured and uninjured sides were 40.0° and 48.95°, respectively ($P < 0.01$). There was no significant difference between sides for ankle plantar flexion and ankle dorsiflexion (Table 5).

DISCUSSION

A brief consideration of the anatomical relationships of the metatarsophalangeal joint will make possible a better understanding of the mechanism of injury and associated joint disruptions in turf-toe injuries. The metatarsophalangeal joint is a condyloid articulation between the concave proximal surface of the proximal phalanx and the rounded head of the metatarsal. The joint capsule is reinforced on the plantar surface by a fibrocartilaginous plate (the volar plate, also known as the plantar accessory ligament)[1,7,11] (Fig. 2). The synovial membrane of the joint capsule is quite lax.[6] The plate attaches distally to the proximal phalanx and proximally to the plantar aspect of the neck of the first metatarsal. The distal attachment is stronger than the metatarsal attachment. The deep transverse metatarsal ligament, the lateral head of the flexor hallucis brevis, and the adductor hallucis all attach to the lateral sesamoid and form the lateral edge of the volar plate. The medial head of the flexor hallucis brevis and the tendon of the abductor hallucis attach to the medial sesamoid. The joint is stabilized on the sides by the collateral ligaments and dorsally by the expansion of the extensor tendon mechanism.

The volar plate contains the two sesamoid bones. The sesamoids function as a fulcrum that increases the mechanical advantage of the flexor hallucis brevis tendons, and they serve as weightbearing points for the metatarsal head.[10] There is very little medial-lateral motion at the metatarsophalangeal joint. There is approximately 30° of flexion and 50° of extension, although range of motion at this joint is highly variable.

The most common mechanism in turf-toe injury is a hyperextension injury to the metatarsophalangeal joint of a foot in a slightly dorsiflexed position (References 1, 3, 4, and unpublished data). During a tackle one player falls across the dorsal surface of another player's leg, the joint is forced into hyperextension. The forefoot is fixed on the ground and the heel is raised in the air (Fig. 3). The joint capsule tears off of the metatarsal head since the attachment is weaker at this site than at the proximal phalanx. Joint kinematic studies reveal compression of the articular cartilage and subchondral bone at the extremes of hyperextension of the first metatarsophalangeal joint.[9] Long-term sequelae may be the result of such joint pathology (discussed below).

TABLE 5
Range of motion at the ankle and first metatarsophalangeal (MTP) joint in injured players ($N = 36$)

	Injured side	Uninjured side
First MTP plantar flexion[a]	22.11	30.79
First MTP dorsiflexion[a]	40.0	48.95
Ankle dorsiflexion	9.17	13.33
Ankle plantar flexion	38.61	36.67

[a] Significant at $P < 0.01$.

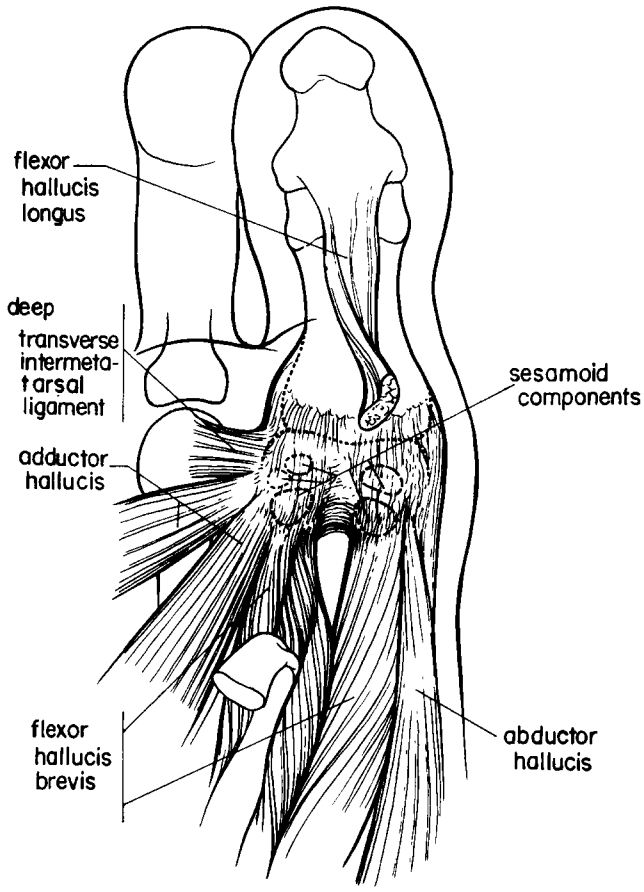

Figure 2. The tendons of the flexor hallucis brevis, adductor hallucis, and abductor hallucis combine with the deep transverse metatarsal ligament to form the fibrocartilaginous plate on the plantar aspect of the metatarsophalangeal joint capsule. The two sesamoid bones are contained within the fibrocartilaginous plate.

Another mechanism of injury to the plantar capsule is hyperflexion. This occurs as the ball carrier is tackled from behind, as the ankle is plantar flexed. A hyperflexion injury results. A third, less common mechanism of injury reported in the literature is a valgus injury.[5] This occurs as a player suddenly accelerates, such as a lineman pushing off from a stance. One author describes turf-toe as a sprain of the collateral ligaments,[5] suggesting a valgus stress.

This study has identified several risk factors for incurring

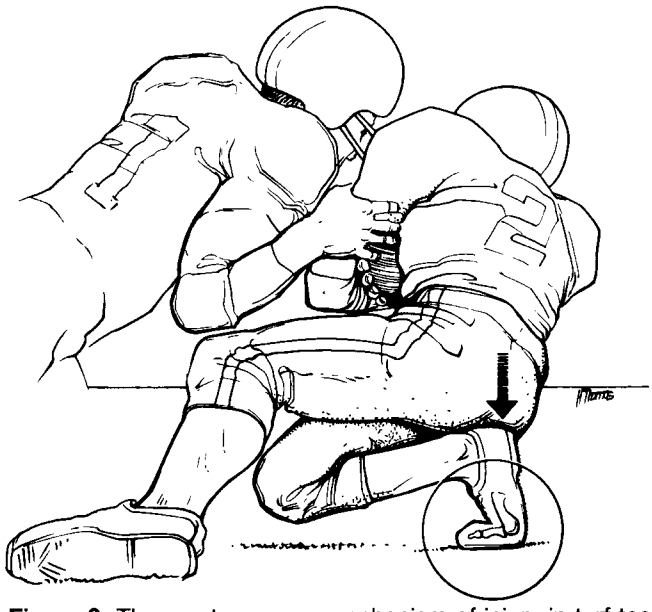

Figure 3. The most common mechanism of injury in turf-toe is a hyperextension injury to the first metatarsophalangeal joint. The joint capsule tears off of the metatarsal head since the attachment is weaker at this site than at the proximal phalanx.

turf-toe injury. This information allows us to describe a profile of the typical player who sustains turf-toe. Such a player is often a running back or offensive lineman, is older and has had a longer career in professional football, and has increased ankle dorsiflexion. We will consider each of these factors in turn.

Turf-toe injuries were more common among offensive linemen in our study. The toe may be injured when pushing off from a stance, which forces the metatarsophalangeal joint into hyperextension. Running backs and receivers may be injured when tackled from behind, as the hyperextension injury usually occurs when the foot is fixed on the ground with the heel raised in the air and another player falls on the back of the player's leg, forcing the joint into hyperextension. Running backs and receivers may also suffer hyperextension injury when making sharp cuts to change direction.

The finding that older players and players who have had a longer professional football career report a significantly higher incidence of turf-toe injury suggests that this injury is exposure related. Similar to many other sports injuries, the athlete's risk of injury is proportional to duration of activity.

A greater range of ankle dorsiflexion was found to be significantly related to the incidence of turf-toe. As the ankle is usually in a slightly dorsiflexed position at the time of injury, such increased ankle dorsiflexion may allow the foot to more readily assume the position in which subsequent loading of the first metatarsophalangeal joint can occur. Further, prospective study of the usual mechanism of turf-toe injury is needed to better delineate the role of ankle range of motion in turf-toe injury.

A pes planus or pronated foot may predispose to turf-toe since this foot configuration assumes heel valgus upon weightbearing. The increased stress placed on the medial side of the foot may predispose to injury of the first metatarsophalangeal joint.

The present study did not find any significant relationship between range of motion of the metatarsophalangeal joint and injury to this area. This finding is in agreement with another study that reported that first metatarsophalangeal joint range of motion was not related to turf-toe injury.[4]

Another factor found to be related to the etiology of turf-toe was playing surface. Our data supports the reports in the literature that have demonstrated turf-toe to be more common on artificial turf than natural grass (References 1, 3, 4, and unpublished data). This is primarily due to the increased hardness and reduced shock-absorbing characteristics of artificial turf compared to natural grass. It has been reported that new Astroturf (MonSanto Co., Houston, TX) approximates natural grass in impact characteristics, but that 5-year-old Astroturf behaves similarly to the asphalt underneath.[2] These hard surfaces transmit the force of a tackle directly to the joint, thereby overloading the plantar capsule ligament and resulting in turf-toe.

Shoe type has also been identified in previous studies as a predisposing factor for turf-toe. The rubber-sole, multicleat shoe is commonly implicated in turf-toe injuries.[1] This shoe is flexible in the distal forefoot region, unlike the conventional seven-cleat football shoe with its rigid sole. It is purported that such flexibility fails to protect the first metatarsophalangeal joint from excessive hyperextension. This would overload the capsuloligamentous complex and result in capsular disruption. However, this study found no difference in shoe type between injured and uninjured players. Perhaps this was due to the small number of players in this study who reported wearing the conventional, rigid-soled football shoe. Further studies are required to clarify the role of shoe type in turf-toe injury.

The second part of this study analyzed the effect of turf-toe injury on the ankle and metatarsophalangeal joint. This study revealed decreased range of motion at the metatarsophalangeal joint as a result of turf-toe injury. This finding demonstrates the possibility of long-term sequelae to turf-toe injury. Hallux rigidus must be considered in an athlete with progressively limited dorsiflexion at the first metatarsophalangeal joint. We have recently reported a case of diastasis of a bipartite sesamoid in a professional football player 1 year subsequent to turf-toe injury when compared to the time of injury (unpublished data). Other possible sequelae include production of dorsal osteophyte[8] (Fig. 4), progressive hallux valgus,[3] calcification in periarticular soft tissue,[4] and chondromalacia of the head of the first metatarsal.[4]

CONCLUSIONS

Although not usually a serious injury, turf-toe is significantly functionally disabling to warrant attention. This study is

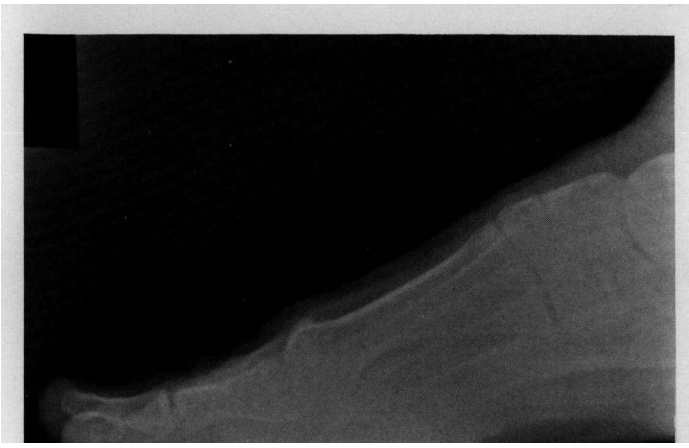

Figure 4. Potential sequelae of metatarsophalangeal joint injuries include development of dorsal osteophyte with associated hallux rigidus.

the first to document the prevalence of turf-toe injuries among professional football players. Forty-five percent of the 80 players from the two professional teams surveyed in this study had incurred a turf-toe injury. Consistent with previous findings, the majority of these players report their initial injury on an artificial surface. This study has identified several risk factors for turf-toe injury. These include player age, number of years in professional football, and range of ankle dorsiflexion. The present study is also the first to document decreased range of motion at the metatarsophalangeal joint subsequent to turf-toe injury. Such loss of motion may predispose to other long-term sequelae. This illustrates the need for appropriate diagnosis and treatment at the time of initial injury.

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