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Turf-Toe: a shoe-surface related football injury

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ABSTRACT. Plantar capsule-ligament sprain of the great toe metatarsophalangeal joint, herein referred to as "turf-toe," is discussed with emphasis on two apparently predisposing factors, playing surface hardness and shoe stiffness. Surface hardness studies have previously been performed by the authors on natural grass and AstroTurf. A study of football shoe flexibility is presented and the results correlated with the occurrence of turf-toe. We have not encountered this entity in players wearing relatively stiff conventional seven posted football shoes or the more flexible soccer style shoe on natural grass fields. We have found it to be a not uncommon injury among players wearing the soccer style shoe on AstroTurf.

METATARSOPHALANGEAL JOINT SPRAIN, ATHLETIC INJURY, SHOE FLEXIBILITY

The installation of AstroTurf on West Virginia University's football field ushered in an entity not previously encountered among our football players, sprain of the plantar capsule-ligament complex of the great toe metatarsophalangeal joint. We have referred to this condition as "turf-toe."

From the beginning of the 1970 season through the 1974 season there were 27 such sprains, an average of 5.4 per year, occurring among a population of five hundred players.

Anatomy. The great toe metatarsophalangeal joint is a condyloid articulation formed by the concave base of the proximal phalanx receiving the rounded metatarsal head. The joint is stabilized on the sides by fan-shaped collateral ligaments and dorsally by the expansion of the extensor tendon mechanism. On the plantar surface stability is afforded by transformation of the capsule into the heavy plantar ligament (2).

Being basically a hinge joint, medial-lateral motion is minimal. From the neutral position there are approximately 30 degrees of flexion and 50 degrees of extension. Forced extension beyond the physiologic limit results in sprain of the plantar capsule-ligament complex.

Mechanism of Injury. In our series the most common mechanism of injury has been a force applied by one player falling onto the posterior lower leg of another as seen in Figure 1. The metatarsophalangeal joint is in extension with the ball of the foot fixed and the heel elevated. The applied force drives the joint into hyperextension producing the sprain.

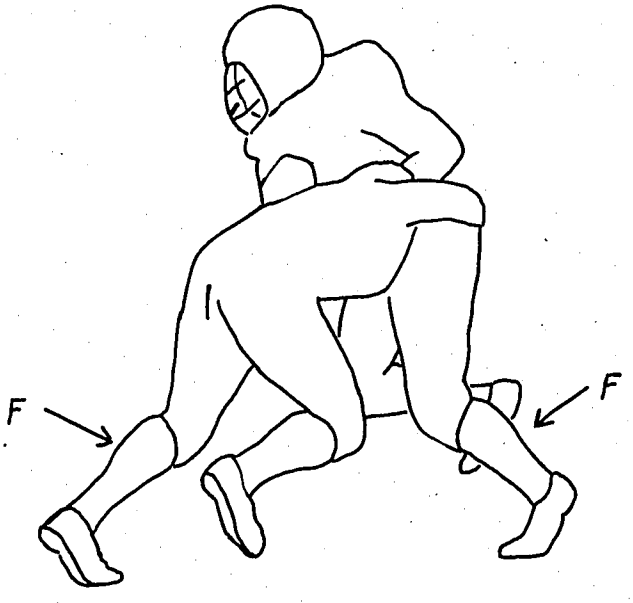

Figure 1—Common mechanism of injury producing "turf-toe." Force (F) drives MP joint into hyperextension, as forefoot is fixed and heel is elevated.

Diagnosis. Initial discomfort varies with the degree of sprain but in all instances pain has become progressively more intense after several hours. Pain and disability may not reach maximum until twenty-four hours following injury. The joint becomes uniformly swollen and the overlying skin tense and hyperemic. Marked point tenderness is noted on the plantar surface especially over the metatarsal head. Passive extension is resisted and produces significant discomfort.

X-ray studies have revealed only generalized soft tissue swelling. No fractures have been encountered.

Treatment. Immediate ice immersion therapy is begun and continued three times daily until swelling and soft tissue reaction have generally subsided. Activity is restricted until discomfort is minimal to absent. As activity is progressively increased, protective taping is maintained and a firm insole insert is added to the shoe.

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Recurrent episodes have occurred and though usually less severe are treated similarly to initial cases.

Contributing Factors. We felt that playing surface hardness and shoe flexibility were the two main factors contributing to this injury. The importance of shoe-surface friction in this regard is at present a matter of conjecture.

Surface hardness studies were performed on natural turf, new AstroTurf and five-year-old used AstroTurf in 1973. The natural surface was found to be less hard than the new AstroTurf and the new much less hard than the AstroTurf which had been in use for five years (1).

The flexibility of three football shoe types was recently determined; the Riddell 45, the Riddell 478 and the Adidas 7921.

The Riddell 45 is a low cut conventional seven posted football shoe with a chrome retan leather sole waterproofed with Actroguard. It has seven removable urethane cleats which attach to the seven posts, two on the heel and five mounted on the metal forefoot plate which contributes significantly to sole stiffness. It has been the conventional natural turf shoe.

The Riddell 478 is a twenty cleated soccer style shoe with a molded urethane sole containing a cast duck material in the middle. This is the shoe West Virginia University players have previously used on artificial surfaces, and the type shoe worn in turf-toe injuries. The Adidas 7921 was included in the flexibility study because we are now using it on artificial surfaces rather than the Riddell 478. It has a molded sole of natural rubber.

Shoe sole flexibility was measured as shown in Figure 2. The posterior portion of the sole was made inflexible by clamping it to a suitably shaped piece of ¾ inch thick wood such that the anterior edge of this support was 15 ± .5 cm from the toe tip. This assembly was then clamped upside down so that the sole heel was horizontal. Using a goniometer device the initial (unloaded) angle of the anterior shoe sole with respect to the heel (or horizontal) was measured as shown. Weights were then hung from the tip of the toe and the amount of flexion noted at each level of applied force until 50 degrees of flexion was exceeded.

The amount of bending moment, M, at each level of loading was calculated using the equation

$$M = 15 \cdot F \cos \Theta \quad \text{(N-cm)}$$

where F is the applied force, in Newtons, and Θ is the angle of flexion.

Twelve shoes were tested: two new and two used pairs of each type, the Riddell 45, Adidas 7921, and the Riddell 478. Typical results are presented in Figure 3 which shows bending moment versus angle of flexion curves for three shoes. The slopes of these non-linear curves represent the stiffness of the shoe, stiffness being of course the inverse of flexibility. Interpretation of these data is complicated by their non-linearity and the fact that a great deal of variability exists in the initial angle of the sole. In order to overcome this and focus on the stiffness of the

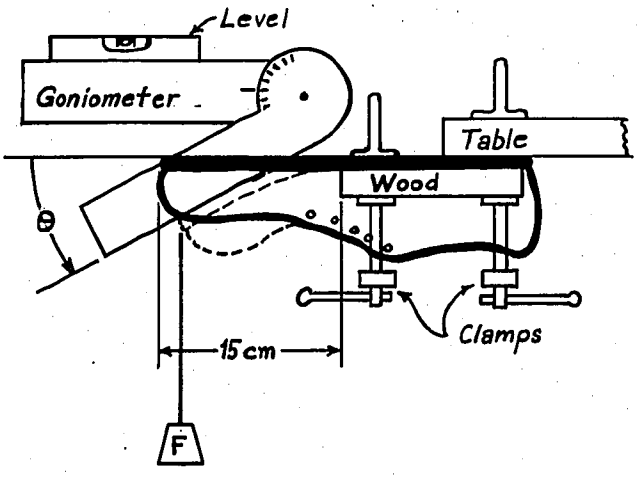

Figure 2–Schematic diagram of shoe flexibility test arrangement.

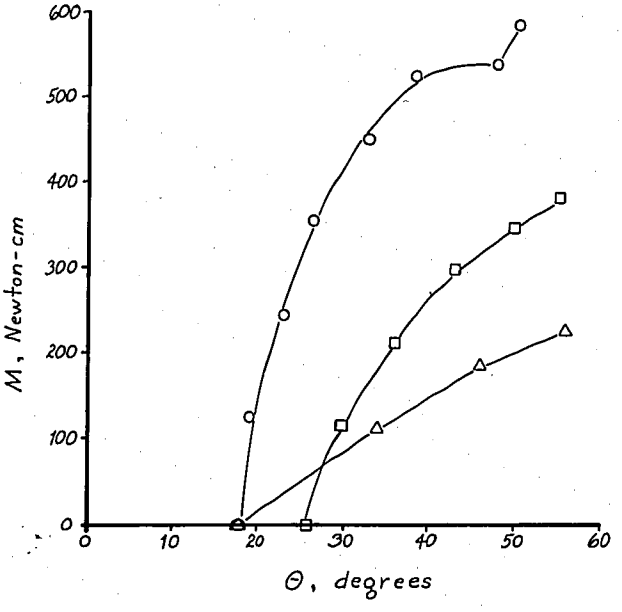

Figure 3–Typical results of shoe flexibility testing. Ordinate is bending moment, M, in Newton-cm. Abcissa is angle of flexion, Θ, in degrees. Curves shown are for a Riddell 45 new shoe, (0), Riddell 45 used shoe (△) and Riddell 478 new shoe (□).

shoe as the physiologic limit of 50 degrees is reached, we calculated the mean slope (or stiffness) of each shoe between its initial state and 50 degrees of shoe flexion (equivalent to 50 degrees of toe extension).

The results are shown in Table 1, which gives the mean stiffness of each shoe type according to whether it was new or used. (In the latter cases we did not know the extent of use, but based on cleat wear all the used shoes had apparently seen much service.) The variations in flexibility within a shoe type are illustrated by the rather large standard deviations. In spite of this variability it was shown that the used shoes are in every case more flexible than new ones of the same type; significance levels for this are P = .01 or better.

TABLE 1A. Summary of shoe stiffness data.

Shoe Type	Mean Stiffness (N-cm/Deg)	Standard Deviation (% of Mean)	P
Riddell 45			
Used	8.4	44%	.001
New	18.2	18%	
Adidas 7921			
Used	5.8	28%	.001
New	12.3	16%	
Riddell 478			
Used	4.6	45%	.010
New	9.6	34%	

TABLE 1B. P values for different mean values.

Shoe Types	P
Used Shoes	
Riddell 45, Adidas 7921	.20
Riddell 45, Riddell 478	.075
Riddell 478, Adidas 7921	.37
New Shoes	
Riddell 45, Adidas 7921	.002
Riddell 45, Riddell 478	<.001
Riddell 478, Adidas 7921	.16

Comparing new shoes of different types, one finds that the Riddell 45 is significantly less flexible than both the Adidas ($P = .002$) and the Riddell 478 ($P < .001$). The latter shoe appears to be more flexible than the Adidas model, but there is a 16% chance that this observation is wrong.

Comparing the used shoes of different types, one finds that their flexibility ranking is the same as for new shoes, but the differing degrees of wear reduce the statistical significance of the ranking. It is probable that the three shoe types maintain their relative flexibility ranking with use, but the usual statistical criteria for establishing this are not satisfied.

DISCUSSION

That a direct shoe-surface relationship exists in the causation of turf-toe seems clear. We can document no such trauma as having occurred among players wearing either the conventional seven posted or soccer style shoe on natural turf. We have encountered it exclusively in players wearing the soccer style shoe on AstroTurf.

One of the authors (K. Douglas Bowers) sees all football injuries from three area high schools. These teams comprise a total player population averaging one hundred yearly, and all games and practice sessions occur on natural turf. Exact numbers could not be determined, but we were able to ascertain that the majority of players have worn the conventional seven posted shoe, a minority, the soccer style shoe. There have been no great toe metatarsophalangeal joint sprains from this group during the past three years.

At a nearby college (Waynesburg, Pa.) 216 players have used the soccer style shoe (Riddell 478) exclusively for the past three seasons, playing only on natural turf. Their team physician has not encountered this entity (personal communication from A. J. Patterson, M.D.).

On the basis of this study, we have determined that the combination of a relatively flexible football shoe with a relatively hard artificial playing surface, predisposes to this type of injury.

Turf-toe results in significant functional disability. Pushoff, all important in football, is markedly impaired. Forward drive and running are compromised and affected players have difficulty assuming the down position. Though minor sprains result in limited activity for only several days, severe sprains have prevented affective participation for up to two weeks.

CONCLUSIONS

1. Turf-toe is a distinct shoe-surface related clinical entity, the combination of the relatively flexible soccer style shoe with a hard artificial surface predisposing to its occurrence.
2. The conventional seven posted football shoe (Riddell 45) is less flexible than the soccer style (Riddell 478) and Adidas 7921 football shoes.
3. With use, the flexibility of all shoes tested increases.
4. Turf-toe, though not a serious injury, is significantly disabling functionally to warrant attempts at its prevention.
5. The use of a relatively firm-soled football shoe on hard artificial playing surfaces is recommended to reduce the incidence of turf-toe.

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