

FOOTBALL SHOE DESIGNS MAY AFFECT LOWER EXTREMITY INJURY RISK

Mark R Villwock, Eric G Meyer, John W Powell, Amy J Fouty, Roger C Haut

Michigan State University, East Lansing, MI, USA

E-mail: haut@msu.edu, Web: www.obl.msu.edu

INTRODUCTION

High torsional friction between football shoes and the playing surface yields a potential for injury to the lower extremity (Torg et al., 1974). A study on the effect of four cleat designs on ACL injury rates determined that the cleat category with the highest torsional moment was associated with an ACL injury rate 3.4 times higher than all other cleat designs combined (Lambson et al., 1996).

Although the torsional friction of shoe-surface interfaces has been documented, it has been limited by non-portable testing equipment (Cawley et al., 2003), a small number of cleated shoes (Livesay et al., 2006), and forefoot only cleat engagement with small compressive loads (Lambson et al., 1996; Livesay et al., 2006).

The current study developed a mobile testing apparatus to measure the torque produced at the shoe/surface interface and the relative shoe rotation for ten football shoes representing five cleat design categories. It was hypothesized that shoes with numerous and/or large cleats around the peripheral margin of the sole would have higher torsional resistance than shoes with fewer or smaller cleats on the periphery.

METHODS

The testing method conformed to the ASTM standard method for traction characteristics of an athletic shoe-surface interface (F2333). A static compressive load of 1000N and a dynamic 90° external rotation were applied to shoes mounted on a rigid footform.

Additionally, a compliant ankle joint was developed to better represent the *in vivo* loading scenario at the shoe-surface interface.

Ten football shoes (Figure 1) were tested on sixteen surfaces, (14 infill based synthetic surfaces and 2 natural grass plots). Five trials were conducted on fresh sections of turf resulting in a total n=80 for each shoe. Rotational interface stiffness was computed as the slope of the torque versus shoe rotation plot between the onset of the test and 75% of peak torque. Peak torque and rotational interface stiffness were compared between shoe models and groups using an ANOVA followed by SNK post-hoc tests, when appropriate.

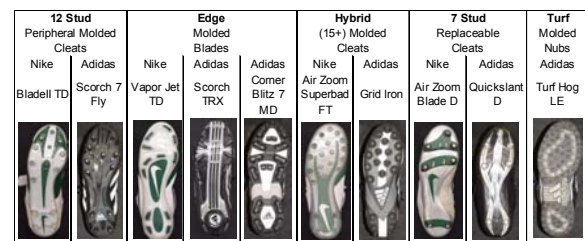


Figure 1: Description of tested shoes.

RESULTS AND DISCUSSION

Peak torques were significantly affected by the model and cleat design of the football shoe (Figure 2). The cleat group category with perimeter cleats (12 Stud and Edge) produced the highest torques in this study, comparable to the results of Lambson et al. (1996). Additionally, Blade II, a member of the 12 stud group, resulted in a significantly higher mean torque than the other perimeter cleat models. This may be due to the increased cleat length on this shoe, similar to

a previously documented relationship between cleat length and peak torque (Torg, 1974).

The highest rotational stiffnesses (Blitz and Grid Iron) were associated with large rubber cleats, and perhaps more importantly, the most rigid uppers and soles (Table 1). By comparison, the shoe with the lowest stiffness (Superbad) had a relatively pliable upper and sole, making it more capable of rotating on the rigid footform. This caused the leading edge of the shoe to dig into the ground and create a “snowplow” effect with the infill material. This gradual buildup of infill posed an additional source of torsional resistance that occurred after breakaway. This increase in rotation before reaching peak torque resulted in a lower stiffness for this particular shoe.

Livesay et al (2006) measured the rotational interface stiffness of different shoe-surface combinations, but only using forefoot cleats rigidly mounted on a plate. The results of the present study indicate that rotational interface stiffness of whole shoes may be a function of shoe fit as well as its ability to resist rotation about the mid-foot.

Table 1: Mean stiffness (Nm/deg).

* significantly different from all models.

12 Stud		Edge			Hybrid		7 Stud		Turf
Bladell	7Fly	Vapor	TRX	Blitz	Superbad	GridIron	BladeD	Qslant	TurfHog
3.2	3.3	3.1	2.9	4.0*	2.2*	3.9*	3.0	2.9	3.0

SUMMARY/CONCLUSIONS

Generation of excessive torque at the shoe-surface interface was a product of the cleat shape, length, and layout. The peak torques measured in the current study exceeded injury levels based on cadaveric studies (Hirsch and Lewis, 1965). However, muscle stiffness has been shown to protect the lower extremity at similar torques (Shoemaker, 1988). Future studies, using a more biofidelic ankle, may help establish

relationships between shoe-surface interfaces and the potential for ankle injury. Additionally, epidemiological studies of shoe and surface injury rates will be important for validating the predicted injury risk for various shoe-surface interfaces.

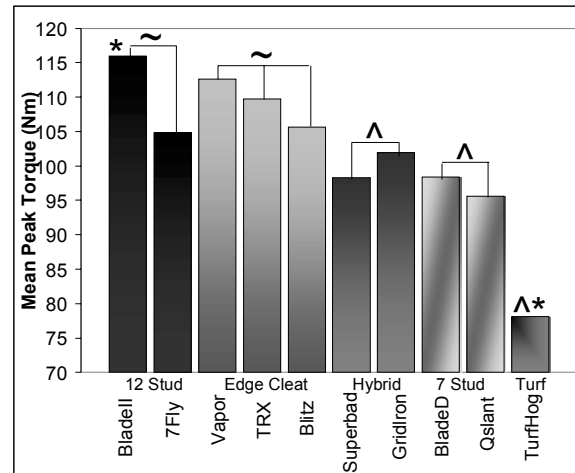


Figure 2: Peak torques for all shoe models
* significantly different from all models,
^ significantly different from all groups,
~ significantly different from Hybrid, 7 Stud, and Turf groups.

REFERENCES

- Cawley, P.W. et al. (2003). *Foot Ankle Int*, **24**(7), 551-556.
- Hirsch, C., Lewis, J. (1965). *Acta Orthop Scand*, **36**(4), 408-417
- Lambson, R.B. et al. (1996). *Am J Sports Med*, **24**(2), 155-159.
- Livesay, G.A. et al. (2006). *Am J Sports Med*, **34**(3), 415-422.
- Shoemaker, S.C. et al. (1988). *Clin Orthop Relat Res*, **228**, 164-170
- Torg, J.S. et al. (1974). *J Sports Med*, **2**(5), 261-269.

ACKNOWLEDGEMENTS

This study was funded by a grant from the NFL Charities Foundation. The authors thank General Sports Venue, LLC for installation of the GameDay surfaces at MSU.