Football boot sole configurations and their influence upon surface adhesion

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Introduction

When running during soccer play it is important to obtain sufficient rotational and translation resistance to achieve good adhesion to the playing surface. A narrow relationship exists between these two components but it is not perfect (Nigg, 1987).

One of the most frequent injuries that occur during a football match comes from trauma brought about by torsion of the leg. This trauma occurrs frequently at the time of pivotal rotation when the foot is stationary (Torg & Quedenfeld, 1971; Cameron & al., 1973; Andreasson and al., 1986). Injuries vary from damage to the knee's cartilage and ligaments to fractures of the tibia bone. Two thirds of the injuries in soccer are linked to the interaction between the playing surface and the football boot (Nigg, 1987).

Adhesion to the surface is important and should be considered both in translation and rotation (Nigg et al.1987). It is therefore important to achieve optimum adhesion, not necessarily a maximum. (Stucke et al 1984; Valiant 1993).

It has been noted by Valiant that:

- The friction coefficient in translation must be high enough to allow acceleration and the rapid changes of direction required for high performance.
- Adhesion in rotation must be the lowest possible in order to avoid blockage of the boot at the time of a rotation.

The objective of this test evaluation was to examine how the boot sole configuration influences adhesion on three types of football surface.

Methodology

Rotational resistance

The rotational resistance was determined from the torque required to rotate a weighted sole in contact with the surface. The sole (figure 3) was loaded with a mass of 45 kg (441 N) and dropped onto the surface from a height of 100 mm; the peak torque to initiate rotation was then measured (figure 1) using a lever arm and a torque transducer type Armstong 64-402. Five measurements were made at different locations on the surfaces.

Figure 1. Rotational resistance apparatus

Translation resistance

The translation resistance was determined using a boot fastened to a plate and pulled along the horizontal surface of the sample as in Fig. 2. The plate was loaded with 15,9 kg mass and the maximum pulling force was noted visually on the spring scale. The sliding friction was calculated by dividing the maximum pulling force by the vertical load. The friction was measured for three shoe soles (figure 3).

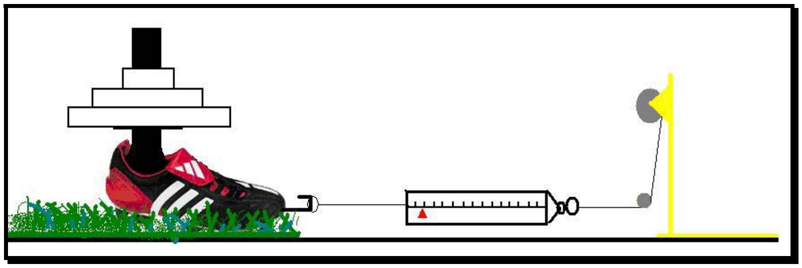

Figure 2. Translational measurement apparatus.

Pimples Molded Blades

Figure 3. Boot soles used in translation and rotational resistance measurements

Surface description

Surface 1 = Natural turf
Surface 2 = Infill artificial turf, FIFA recommended, 5 years old
Surface 3 = No infill surface XL Generation

Uncertainty in Measurements

The uncertainty in the measurements was calculated at the 95 % confidence level using the results from the sets of five measurements. These confidence intervals are indicated on the graphs of the results. In most cases it is about 10 – 15 %.

Results

Torques

In Figure 4 and Table 1 are shown the relationships between the measured torques and the three types of surfaces and soles.
It is apparent that the torques developed the natural surface (1) seems independent of the type of soles used when compared to surfaces 2 and 3. The torque to initiate movement for the natural surface appear fairly constant varying only between 32 Nm and 33 Nm.
The infill surface (2) exhibits a higher torque for the molded sole, there being no significant difference between the torques for molded and blade soles. Nevertheless, there is a significant difference between the pimpled sole and molded sole, the latter requiring greater torques to initiate movement.

Surface 3 without infill gave a torque of 35 Nm for pimple soles compared to 24 Nm for blades. The difference between these two types of soles is significant.

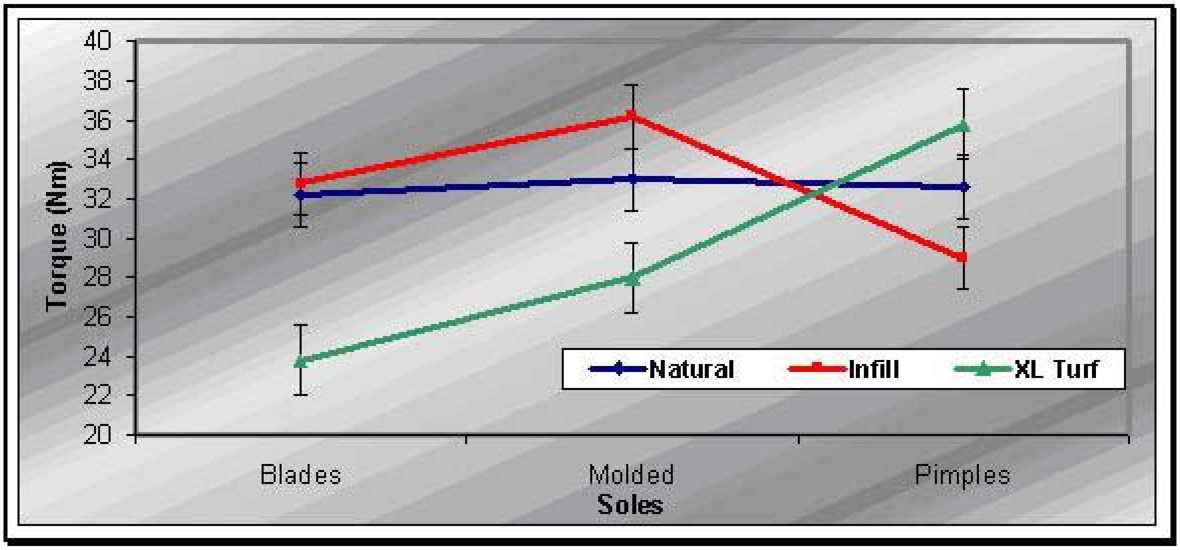

Figure 4. Rotational resistance relationship.

Table 1. Average torque for each sole, surface and interaction.

Groups	Observations	Mean	Lower limit	Upper limit
Surface				
Natural	15	32,6	30,8	34,4
Infill	15	32,7	30,8	34,5
Without infill	15	29,2	27,4	31,0
Soles				
Molded	15	32,4	30,6	34,2
Blades	15	29,6	27,8	31,4
Pimples	15	32,5	30,7	34,2
Surface by Sole				
Natural-Molded	5	33,0	29,9	36,1
Natural-Blades	5	32,2	29,1	35,3
Natural-Pimples	5	32,6	29,5	35,7
Infill-Molded	5	36,2	33,1	39,3
Infill-Blades	5	32,8	29,7	35,9
Infill-Pimples	5	29,0	25,9	32,1
Without Infill-Molded	5	28,0	24,9	31,1
Without Infill-Blades	5	23,8	20,7	26,9
Without Infill-Pimples	5	35,8	32,7	38,9

Translation forces

The results for translation measurements (Fig. 5 and Table 2) show that the choice of sole is not a major influence for the natural and infill surface when compared to that of the non-infill surface (3). For the natural surface, the friction coefficient varies between 0,64 and 0,72. For the infill surface, the coefficients are between 0,76 and 0,85. The more interesting results are for surface 3 (without infill); this shows the type of sole used has a direct impact on the measured coefficient of friction. For this surface a blade sole has a friction coefficient of 0,70 whilst a molded stud sole has a coefficient of 0,81 and a pimple sole 1,1.

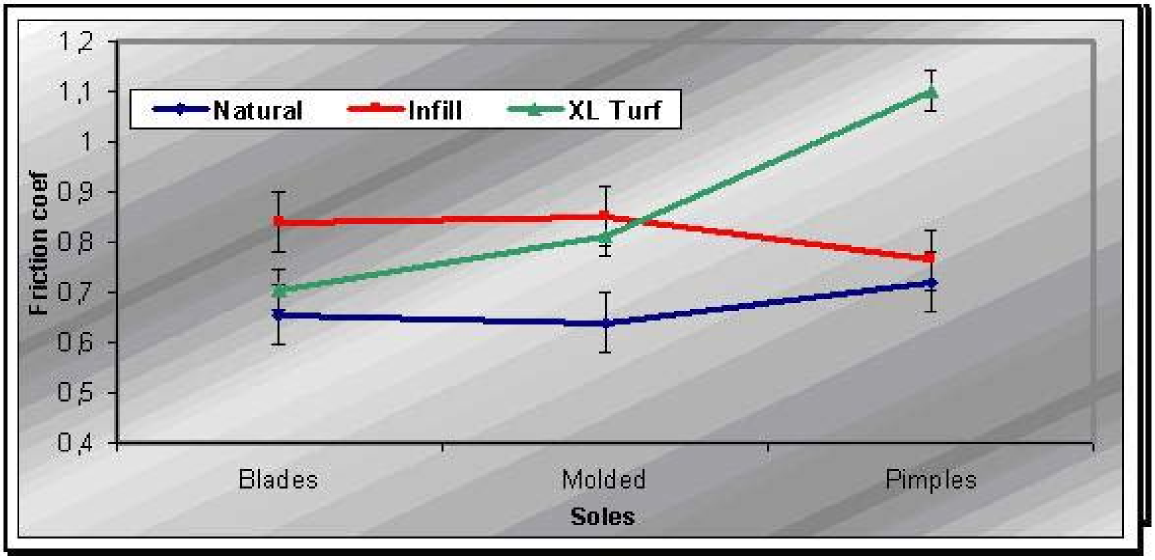

Figure 5. Interaction between 3 types of surfaces and 3 types of soles on the resistance in translation.

Table 2. Average friction coefficient for each sole, surface and interaction.

Groups	Observations	Mean	Lower limit	Upper limit
Surface				
Natural	15	0,67	0,64	0,69
Infill	15	0,78	0,76	0,81
Without infill	15	0,99	0,97	1,02
Soles				
Molded	15	0,80	0,78	0,83
Blades	15	0,73	0,71	0,76
Pimples	15	0,91	0,89	0,93
Surface by Sole				
Natural-Molded	5	0,64	0,60	0,68
Natural-Blades	5	0,65	0,61	0,70
Natural-Pimples	5	0,72	0,68	0,76
Infill-Molded	5	0,85	0,70	0,79
Infill-Blades	5	0,83	0,80	0,88
Infill-Pimples	5	0,76	0,72	0,80
Without Infill-Molded	5	O,81	0,75	0,90
Without Infill-Blades	5	0,70	0,66	0,96
Without Infill-Pimples	5	1,10	0,89	1,31

Table 3. Realistic and acceptable surface-soles combination.

Realistic combination (surface-sole)	*Torque (Nm)*	*Friction coefficient (μ)*
Natural vs Blades	32,2	0,65
Natural vs Molded	33,0	0,64
XL Turf vs Pimples	35,8	1,10
XL Turf vs Molded	28,0	0,81

Discussion

The two test methods used clearly indicate that a soles interaction with a surface must take into account the two principal components – torques and translation forces (Nigg et al 1995). Several organizations use only one component and hence the propensity for different materials and sole designs (plastic, rubber, Teflon, metal and blades, molded, pimple, flat) since there is only one set of criteria to meet. Several studies (Bonsting et al., 1975; Andreasson et al., 1986; Heidt et al., 1996) clearly show the significance of the torque and of friction coefficients, and supports the results obtained here.

An hypothesis to explain the grip on the non infill surface might be that the principal factors affecting adhesion to the non-infill surface are fiber density and the interaction between the sole design and the materials used. This hypothesis is confirmed by the results achieved at Calgary Laboratories during spring 2002 on 22 artificial surfaces (Stefanyshyn & al., 2002). During these experiments, two surfaces without infill were characterized by higher friction coefficients for boots without studs (coef =1,98) than boots with studs (coef = 1,71). For the majority of synthetic surfaces using polyethylene fibre, the use of blades or studs of hard plastic, Teflon or metal does not offer as much adhesion as do studs or blades of softer and porous materials such as rubber molded and pimpled soles.

Conclusion

The results above indicate that the natural surface tested exhibited a resistance in rotation between 32 and 33 Nm with the three types of soles. The condition of this natural surface was hard and compact and for a softer natural turf, the results may be higher due to a higher penetration of the cleats.

It is important hen to use different soles to evaluate the performance of a surface especially if penetration of the surface does not occur. In reality players can choose a shoe-surface combination to obtain the same performance as that achieved on natural grass. It is a recommendation that the test criteria be changed to include testing of both translation and rotational friction across a broad range of sole designs to allow realistic comparison. To reproduce the effects of natural grass the sole type may need to be changed.

A good surface will be the one that offers the optimum adhesion in translation and most probably the lowest in rotation (Valiant 1993). It can be seen from table 3 that a surface without infill can offer the same security (torque) as a natural surface whilst obtaining an equivalent or superior friction coefficient.

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