STUD LENGTH AND STUD GEOMETRY OF SOCCER BOOTS INFLUENCE RUNNING PERFORMANCE ON THIRD GENERATION ARTIFICIAL TURF

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The purpose of this study was to evaluate the influence of different stud lengths and stud geometries of soccer boots on soccer specific running performance. The study involved performance testing by running through two functional traction courses and corresponding subjective testing. Variables of this study were objectively measured running times and perception ratings of running performance. 15 experienced soccer players participated in the study. Players run slower when performing with shorter studs ($p<0.01$). Here, measured running times were reflected by players' perception ($p<0.01$). For stud geometry, bladed studs were more supportive with regard to objectively measured running performance compared to elliptic studs ($p<0.05$). In contrast, no differences were found with regard to players' perception ($p=0.19$). In conclusion, longer stud length provides better traction resulting in better performance. Bladed studs provide a functional traction advantage compared to elliptic studs with respect to running performance.

KEY WORDS: soccer, stud configuration, traction, running time, perception.

INTRODUCTION:

In soccer the player-surface interaction is a central performance aspect, which is influenced by the sole configuration of the boot and the surface. Dependent on external factors like surface conditions suited soccer shoes may vary in stud length. Longer studs are suited for wet and deep surfaces, shorter studs for dry and hard surfaces. These variations are important when playing on natural grass. Additionally, different stud positioning, stud geometries and also different numbers of studs are available for soccer shoes. All these factors may affect playing (running) performance and also injury prevention. Thus, the sole configuration of a soccer boot plays an important role with regard to the functionality of traction properties. Sole configurations that provide unsuitable low traction properties increase the risk of slipping. Sole configurations may also provide unsuitable high traction, thus increasing injury potential. In several studies it was shown that different sole/traction configurations effect running speed (Krahenbuhl 1974, Müller et al. 2008, Sterzing et al. 2009). Krahenbuhl (1974) showed a performance benefit for soft ground design compared to multicleated design and tennis shoes on natural grass. Müller et al. (2008) found out, that plane and not so aggressive stud configurations enable players to run faster on artificial turf. In a series of eight studies Sterzing et al. (2009) summarized performance differences for various sole configurations on different surface conditions.

Since 2004 high quality types of third generation artificial turf have been approved for official game play by the FIFA (FIFA 2007). However, the influence of stud lengths and stud geometries with regard to performance benefit on artificial turf is not well understood and thus need to be investigated.

Therefore, the objective of this study was to examine the effect of different stud lengths and different stud geometries on traction properties during running and to evaluate corresponding perception of players. Furthermore, players were asked to assess the traction suitability of the different shoe conditions on the given surface.

METHODS:

15 experienced soccer players (age: 22.8 ± 1.5 years; height: 175.9 ± 4.2 cm; weight: 70.8 ± 3.4 kg) participated in both studies. The artificial turf used in both studies was *LigaTurf 240 22/4 RPU brown* (Polytan, Burgheim/Germany), which is considered to be state of the art 2-Star artificial soccer turf.

Figure 1: Shoe conditions (a)

Figure 2: Shoe conditions (b)

(a) Stud length
The basic shoe model was the *Nike Mercurial Vapor II*. Three different stud lengths were investigated: 100% stud length (NM 100), which marked the regular stud length, 50% stud length (NM 50) with studs shortened to half of the regular length and 0% stud length (NM 0) with studs completely removed (no studs). Reduction of stud length was performed by an orthopaedic shoe technician who abraded the studs (Figure 1).

(b) Stud geometry
The basic shoe model was the *Nike Tiempo Premier*. One version had elliptic studs and the other one had bladed studs (Figure 2). A specification of the stud geometry is displayed in table 1.

Table 1: Stud specification of the shoe conditions

	NM 100		NM 50		NM 0		Elliptic		Bladed	
	rearfoot	forefoot	rearfoot	forefoot	rearfoot	forefoot	rearfoot	forefoot	rearfoot	forefoot
Numbers of studs	4	8	4	8	0	0	4	8	4	9
∑ Medial edged contact surface of the studs [cm^2]	8.2	8.4	4.1	4.2	0.0	0.0	3.6	4.6	4.9	4.8
∑ Lateral edged contact surface of the studs [cm^2]	8.2	9.8	4.1	4.9	0.0	0.0	3.6	6.2	4.9	6.4

The shoe upper was equal for shoe conditions of both studies. Both studies incorporated a performance testing and a subjective testing protocol.

1. Running Performance Testing:
For running performance testing the subjects ran through two different soccer-specific functional traction courses, slalom and acceleration, as fast as possible (Figure 3). The slalom course had a total length of 26 m containing 11 cutting and 12 acceleration movements. Subjects had to go through the course three times in each shoe condition. Shoe order was randomized and shoes were changed after each single run. A rest of two minutes was mandatory after each run in order to prevent the subjects from getting fatigued. The acceleration course had a total length of 6 m requiring the subjects to perform maximum acceleration. The testing procedure was the same as for the slalom course. Running times were measured by double light barriers (TAG Heuer, Marin-Epagnier/Switzerland). After performing all the required runs of each running course subjects were asked to give a speed ranking of the investigated shoe condition for the respective course (fastest performance to slowest performance).

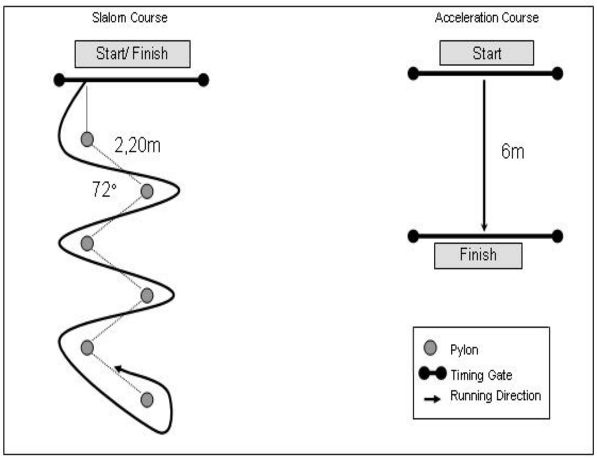

Figure 3: Functional traction courses

2. Subjective Testing of Traction Suitability:
For subjective testing of traction suitability the subjects performed soccer specific movements with the different shoe conditions, e.g. maximum straight accelerations, complete stops, cutting movements to the left and right, and turning movements. The subjects then rated their perceived traction suitability of each soccer shoe model on a nine-point perception scale. The traction suitability testing was categorized in intensity of traction (1-high to 5-neutral to 9-low) and liking of traction (1-good to 5-neutral to 9-bad) (NSRL 2003).
Means and standard deviations for all running time variables were calculated. These were analyzed using a one-way repeated measure ANOVA for comparing shoe-surface characteristics. Post-hoc analyses were applied when appropriate according to Fisher's LSD. The level of significance was set to $p<0.05$ and $p<0.01$. For subjective variables mean ranks (Friedman-test) and medians were calculated.

RESULTS AND DISCUSSION:

(a) Stud length
In both courses subjects run slowest ($p<0.01$) when wearing the NM0 condition (Figure 4). In addition, NM0 was clearly perceived to exhibit the slowest running times in the slalom and in the acceleration task. In the NM100 subjects ran faster ($p<0.01$) which was also clearly perceived by the subjects ($p<0.01$).

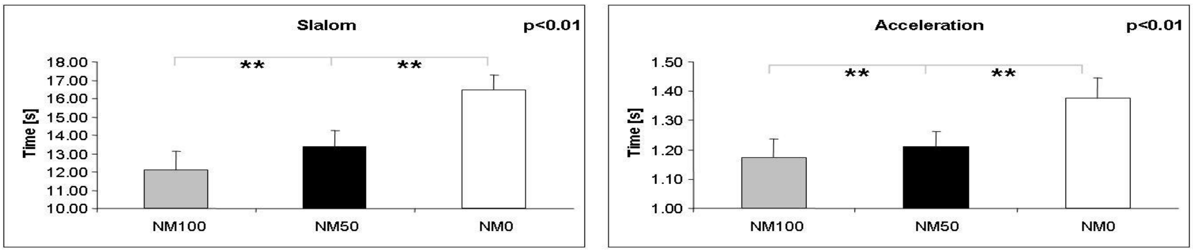

Figure 4: Slalom and acceleration running times - stud length (p<0.01)**

The NM100 was rated to be the best suited traction design with regard to traction intensity and traction liking ($p<0.01$) whereas the NM0 was rated to be the least suited traction design among the three shoes in this study.

Table 2: Speed ranking (1-fastest to 3-slowest), Traction rating (1-high/good to 9-low/bad)

		NM100	NM50	NM0
Speed ranking slalom	[mean rank]	1.07	1.93	3.00
Speed ranking acceleration	[mean rank]	1.13	1.87	3.00
Traction intensity	[median]	1	5	9
Traction liking	[median]	2	5	9

(b) *Stud geometry*
With the bladed design the subjects ran faster in the slalom course ($p<0.05$) compared to the elliptic design. In the speed ranking the subjects perceived statistically no differences between the two types of shoes. In acceleration task no statistical differences were found between the two types of shoes with regard to running time and speed ranking.

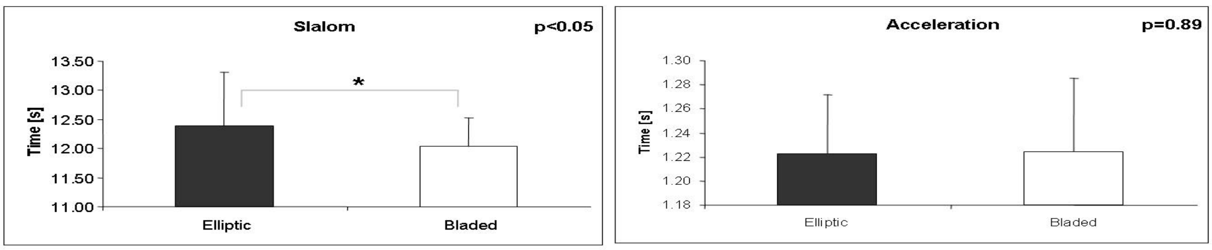

Figure 5: Slalom and acceleration running times - stud geometry (* p<0.05)

The subjects rated the bladed design to be the better suited traction design with regard to traction intensity and traction liking ($p<0.01$).

Table 3: Speed ranking (1-fastest to 2-slowest), Traction rating (1-high/good to 9-low/bad)

		Elliptic	Bladed
Speed ranking slalom	[mean rank]	1.69	1.31
Speed ranking acceleration	[mean rank]	1.70	1.30
Traction intensity	[median]	5	2
Traction liking	[median]	5	3

Lowering the regular stud length on artificial turf influenced subjects' running performance negatively. This is most likely due to the increased risk of slipping during dynamic acceleration and cutting movements. Therefore, it is assumed that subjects performing with NM0 showed more cautious movement behaviour. This movement adaptation strategy resulted in weaker performance (longer running times). The bladed design had a positive effect on running performance compared to the elliptic design. This might be due to the bigger contact surface (Table 1) of the bladed studs allowing more dynamic sideward propulsion. Sterzing & Hennig (2005) also demonstrated a traction benefit for bladed studs compared to elliptic studs. With regard to traction perception, the objectively measured running times are reflected by subjects perception.

CONCLUSION:

Performance and perception testing showed differences between the investigated shoe designs. Stud length affects traction properties of soccer shoes with regard to running performance. This shows that lowering the original stud length while maintaining the regular number of studs decreases performance. In further studies stud lengths between 50% and 100% should be investigated or the length of studs may be even increased in order to quantify the range of stud length that offers best traction. Especially the latter approach needs to have extraordinary caution as injury potential with increase of stud length will increase too. Stud geometry also affects running performance. In the slalom course the bladed stud design shows better performance which is reflected by players' perception. Thus, the geometry of studs is an important factor to develop high level traction conditions. Further enhancement of lateral and medial contact surfaces of bladed studs may result in better performance.

REFERENCES:

FIFA (2007). FIFA – laws of the game 2007/2008. www.fifa.com, (29.11.2007).

Krahenbuhl, G.S. (1974). Speed of movement with varying footwear conditions on synthetic turf and natural grass. *Research Quarterly* 45 (1).

Müller, C., Sterzing, T. & Milani, T.L. (2008). Comprehensive evaluation of player-surface interaction on artificial soccer turf during cutting movements. *26. Symposium International Society of Biomechanics in Sports*, Seoul, Korea.

Nike Sport Research Lab (2003). Product testing and sensory evaluation. Sport Research Review 2.

Sterzing, T., Müller, C., Hennig, E.M. & Milani, T.L. (2009). Actual and perceived running performance in soccer shoes - a series of eight studies. *Footwear Science* (accepted, in press).

Sterzing, T. & Hennig, E. (2005). Stability in soccer shoes: The relationship between perception of stability and biomechanical parameters, *Science and Football V*, T. Reilly, J. Cabri, D. Araujo, London/New York, Routledge Taylor and Francis Group.