EVALUATION OF PLAYER-SURFACE INTERACTION ON ARTIFICIAL SOCCER TURF DURING CUTTING MOVEMENTS

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The purpose of this study was to evaluate the traction characteristics of four different stud configurations on 2-Star, third generation artificial soccer turf during cutting movements. Traction, among others, characterizes player-surface interaction and is a key for top level performance in soccer. The concept of this study involves a combination of performance, subjective-sensory and biomechanical testing. Parameters of this study were: running times, subjective rankings and ratings and ground reaction forces. A subject pool of 26 soccer players was available for the study. The results show that subjects run slower, perceive worse, and evoke lower shear force values in soft ground design ($p<0.01$). It is concluded that a hard ground or partly a firm ground stud configuration is better suited than a soft ground stud configuration for playing on artificial turf. In this study, number, geometry and positioning of studs were the important aspects to achieve good and functional traction. With regard to methodological considerations, the combined approach consisting of three interdependent studies shows valuable and necessary insight of traction properties of different shoe-surface interfaces.

KEY WORDS: footwear, stud configuration, traction, artificial surface, soccer

INTRODUCTION:

In recent years the type and quality of artificial soccer turf have been substantially improved. This is due to a more sophisticated artificial turf technology using an infill system with a bottom layer of sand and an upper layer of rubber. Today, artificial turf is used for practice and also for official top league game play in soccer. High quality types of artificial turf have been approved for official game play by the FIFA since 2004. Artificial surfaces are licensed as 1-Star or 2-Star by the FIFA. A game analysis by the FIFA comparing game play on natural grass to artificial turf claimed the similarity of both surfaces with regard to game characteristics (FIFA, 2007). In comparison Müller et al. (2007) showed that there are differences in playing on artificial turf or natural grass according to players´ perception. Among others, these differences involve accuracy of passes and general speed of the game. Ekstrand et al. (2006) showed that injury rates in general do not differ on artificial turf compared to natural grass. However, there might be a shift in type of injury towards more ankle injuries on artificial turf (Ekstrand et al., 2006).

The player-surface interface is characterized by the surface and the stud configuration of soccer shoes. A key issue for the player-surface interaction are the traction characteristics (Less, 1996). The influence of current artificial turf pitches on the nature of the game and the loads to the human body are not fully understood. Right now, players use soccer shoes with stud configurations designed for playing on natural grass, mainly firm ground designs. Valiant (1987) investigated biomechanical traction properties on artificial turf. It was shown that the highest shear forces occur during rapid stops and cutting movements.

Comprehensive assessment of athletic footwear requires subjective-sensory, biomechanical and mechanical testing (Lafortune, 2001; Sterzing et al., 2007). Sterzing & Hennig (2005) reported the correlation between subjective-sensory parameters and biomechanical parameters with respect to traction and stability characteristics of soccer shoes. They found that bladed studs were perceived to provide higher traction than elliptic studs when comparing firm ground stud designs. Performance testing allows investigating the functionality of traction characteristics by use of time parameters. Krahenbuhl (1974) investigated the performance of football, soccer and tennis shoes on natural grass and artificial turf with regard to running time during running through an obstacle course. It was shown that the different shoe types produced different running times. The purpose of this study is to evaluate the traction characteristics of four stud designs with regard to cutting movements on artificial turf.

METHODS:
Four stud designs were examined with regard to their traction properties (Figure 1): hard ground design (HG), firm ground design (FG), soft ground design (SG), and an innovative design (ID). The shoe uppers of the shoe conditions were the same or almost equal.

Hard Ground (HG) | Firm Ground (FG) | Soft Ground (SG) | Innovative Design (ID)

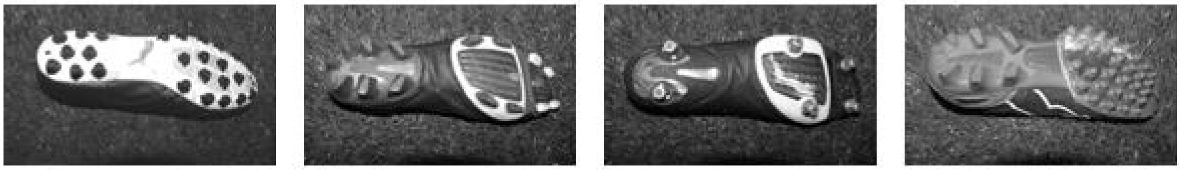


Figure 1: Stud configurations

The artificial turf used in the studies was *Polytan Liga Turf 240 22/4 RPU brown* (Polytan, Burgheim/Germany), which was constructed to meet the requirements of FIFA 2-Star standards. A subject pool of 26 experienced soccer players was available for the different studies (age: 22.85 ±4.1years; height: 177.85 ±4.5cm; weight: 71.54 ±6.3kg). Subjects were required to give informed consent. Prior to data collection a warming-up period and practice trials were mandatory for all testing situations of this investigation. In the following the different test designs are presented. The investigation was divided into three different studies, focussing on performance testing, subjective-sensory testing and biomechanical testing.

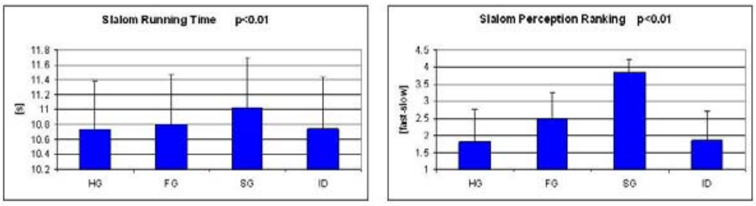
Performance and Subjective-Sensory Testing: Performance testing took place on a testing field (20x5m) at Chemnitz University of Technology and at Stade de Suisse Stadium in Bern during dry weather conditions. Subjects (n=20) ran through a functional traction course as fast as possible. The slalom course had a total length of 26m containing 11 cutting movements 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. Running times were measured by a TAG Heuer (Marin-Epagnier/Switzerland) double light barrier. After finishing all trials of the slalom course, subjects had to rank the four shoe conditions according to their perceived running time (1-fastest to 4-slowest). This allows comparing objective running performance to subjects running time perception.

Subjective-Sensory Testing: After performance testing subjects (n=20) performed several rapid cutting movements observing the suitability of the different traction conditions. Again, the shoes were tested in randomized order. The subjects had to rate the perceived traction suitability of each soccer shoe model on a nine-point perception scale (1-very good to 5-neutral to 9-very bad).

Biomechanical Testing: Subjects (n=18) performed a cutting movement to the left provoking a rapid change of direction towards a pylon (45° of running direction). Five repetitive trials in each shoe condition had to be performed. A wooden box (size: 60x90cm, height of frame: 7cm) containing the artificial turf was installed on a Kistler force plate (Type 9287 BA). The surrounding floor level was elevated in order to match the wooden box height. Shoes were tested in randomized order. The movements were performed with a one step approach as fast as possible for each individual subject, measuring right foot contact to the

ground. Data acquisition was done at a frequency of 1000Hz. Evaluated parameters were vertical force, shear force and the ratio shear force/vertical force.
The statistical analysis involved the calculation of means and standard deviations per shoe condition for all parameters. These were then analyzed with a one-way repeated measure ANOVA. Post-hoc analyses were done according to Fisher's LSD procedure. The level of significance was set to $p<0.05$.

RESULTS AND DISCUSSION:
Performance and Subjective-Sensory Testing: Running times between subjects ranged from 9.32s to 12.59s in the slalom course. In the soft ground design (SG) subjects ran slowest ($p<0.01$). This design was also clearly perceived to exhibit the slowest running time ($p<0.01$). The other shoe conditions show no statistically significant differences in performance among each other. However, the hard ground design (HG) and the innovative design (ID) were perceived to enable players to run faster than the firm ground design ($p<0.05$). In general, perception of running times reflects the measured running times in the slalom course (Figure 2).



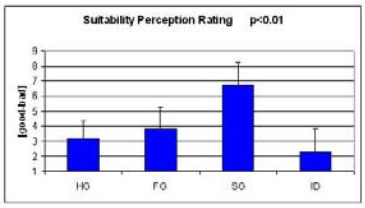


Figure 2: Performance and subjective-sensory testing **Figure 3: Subjective-sensory testing**

The soft ground design (SG) was rated to be the least suited traction design ($p<0.01$) whereas the innovative design (ID) was rated to be the best suited traction design among the four shoes in this study (Figure 3). The hard ground (HG) and firm ground (FG) were rated to be fairly well suited for playing on artificial turf.

Biomechanical Testing: Medio-lateral shear force during cutting ($p<0.01$) is significantly decreased for the soft ground design (SG), whereas vertical force is not affected by the different traction conditions. The ratio shear force/vertical force ($p<0.01$) also shows significantly lower values for the soft ground design (SG).

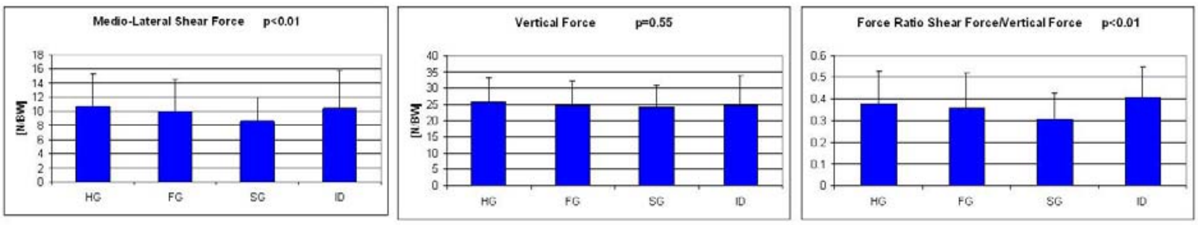


Figure 4: Biomechanical testing

The hard ground design (HG), the innovative design (ID) and to a lesser extent also the firm ground design (FG) show better performance values, better subjective-sensory values and higher biomechanical values. Thus, plane and not so aggressive stud configurations are better suited for playing on artificial turf. Higher shear force values of HG and ID allow more dynamic propulsion during dynamic movements like cutting. In contrast, the longer stud configuration of the soft ground design (SG) provokes worse testing results. It is concluded that the relatively aggressive soft ground design (SG) induces a more cautious movement pattern of players during the cutting movement compared to the other three traction conditions. These findings are supported by the results of Sterzing et al. (2007) showing different outsole configurations effect traction characteristics. Movement styles of players were shown to change due to traction characteristics. The rates of biomechanical values have still not necessarily a proved significance concerning the quality of performance.

CONCLUSION:
The results of these studies show that the hard ground design (HG), the firm ground design (FG), and the innovative design (ID) are suited to be used on artificial turf. The soft ground design (SG) displayed the worst results in the performance testing and in the subjective-sensory testing among the four traction conditions. In biomechanical testing shear force and ratio of shear force divided by vertical force are the most important components to discriminate between traction characteristics (Valiant, 1987). The interdependent results of this study confirm the necessary combination of performance, subjective-sensory and biomechanical testing when assessing athletic footwear, as it strengthens the statement of the results.

REFERENCES:
Ekstrand, J.; Timpka, T. & Hägglund, M. (2006). Risk of injury in elite football played on artificial turf versus natural grass: a prospective two-cohort study. *British Journal of Sports Medicine* 40: 975-980.
FIFA (2007). A comparative performance analysis of games played on artificial (football turf) and grass from the evaluation of UEFA Champions League and UEFA Cup. www.fifa.com.
Krahenbuhl, G.S. (1974). Speed of movement with varying footwear conditions on synthetic turf and natural grass. *Research Quarterly* 45 (1).
Lafortune, M. (2001). Measurement and interpretation of biomechanical, perceptual and mechanical variables. 1. Simpósio Brasileiro de Biomecânica do Calcado, Sociedade Brasileira De Biomecânica, Gramado, Brazil.
Less, A. (1996). The biomechanics of soccer surfaces and equipment. *Science and Soccer*. T.Reilly, E & FN Spon: 135-150.
Müller, C.; Sterzing, T.; Kunde, S. & Milani, T.L. (2007). Das Fußballspiel auf Kunstrasen und Naturrasen. *Jahrestagung der dvs Kommission Fußball*, Kamen, Deutschland.
Sterzing, T. & Hennig, E.M. (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.
Sterzing, T.; Hennig, E.M. & Milani, T.L. (2007). Biomechanical requirements of soccer shoe construction. *Orthopädie-Technik* 9: 646-655.
Valiant, G.A. (1987). Ground reaction forces developed on artificial turf, *Science and football,* T. Reilly, A. Lees, K. Davids, & W.J. Murphy, eds., 406-415. E.& F.N. Spon, London. 1988

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