THE DEVELOPMENT OF A SOCCER SHOE OUTSOLE FOR ARTIFICIAL TURF

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Introduction

The development of artificial soccer turf (AST) has originated in the 1960s (first generation: unfilled) towards the 1980s (second generation: sand filled) until today (third generation: sand and rubber filled). AST of high quality (2-Star certificate) has been permitted for top level game play by the FIFA in 2004. Since then, AST is used increasingly in national championship games and also in FIFA world cup tournaments (U17: Peru 2005, U20: Canada 2007). Addressing performance attributes, FIFA claims game characteristics of AST and natural grass turf (NGT) to be similar. Addressing injury occurrence, no major differences in injury frequency and type on AST compared to NGT in professional European soccer leagues were observed (Ekstrand et al. 2006).

In soccer, there is the demand for specific shoe outsole configurations to provide functional traction for players during different kinds of movements. Traditional outsole and stud concepts were designed for NGT. These concepts are categorized as soft ground (SG), firm ground (FG) and hard ground (HG) recommending the surface conditions on which they should be used. Currently, players use these concepts (predominantly FG and HG) also when playing on AST. However, there is no scientific evidence of the degree of their suitability. Therefore, the purpose of this project was the development of a specific AST outsole concept in two phases.

Methods

In phase I, traction on AST of the three traditional stud concepts (Figure 1a) and of one innovative forefoot DuoCell design (ID) was comprehensively examined. In phase II, traction of three enhanced modifications of the ID shoe was examined (Figure 1b: one example condition). Thereby, especially the functionality of the DuoCell at the rearfoot in contrast to a FG rearfoot design was examined.

Figure 1a: hard ground, firm ground, soft ground (left to right)

Figure 1b: DCDC 90

A comprehensive testing protocol (Hennig & Milani 1996, Lafortune 2001, Sterzing et al. 2007) was used in both phases of this project. Motor performance, subjective, biomechanical, and mechanical studies were performed on highest quality of AST, *Polytan Liga Turf 240 22/4 RPU brown* (Polytan, Burgheim/Germany). Motor performance field testing measured running times and related subjects' perception (speed ranking: 1-best, 4 worst) of slalom (SLA) runs (Sterzing et al. 2009). Subjective field testing asked for perceived suitability of the different outsole configurations (nine-point perception scale: 1-very good, 5-neutral, 9-very bad). Biomechanical laboratory testing measured ground reaction forces (*Kistler 9287 BA*, 1 kHz) during rapid cutting movements (45° change of direction) and the peak force ratio of medio-lateral and vertical force was calculated. For subject testing a pool of altogether 37 (23.0 ± 3.4 years, 177.4 ± 4.3 cm, 71.4 ± 6.1 kg) experienced soccer players was available. Mechanical testing simulated the cutting movement on a two-axis servo-hydraulic testing machine and horizontal force rate (HFR) was measured.

Results and Discussion

Phase I showed better traction functionality of the FG, HG, and ID shoe conditions compared to the SG condition during soccer movements on AST (Table 1). In the SG condition players actually ran and also perceived their running slower. SG suitability perception was lower compared to the other shoe conditions. Biomechanical testing revealed decreased ground reaction forces during cutting for the SG condition, whereas mechanical testing showed higher mechanical traction values. In summary, the SG stud configuration is too aggressive for use on AST, thus providing unfunctional traction. This forced players to generate more cautious, less dynamic movement patterns. Among the other three shoe conditions the HG and ID were found to slightly better respond to the demands of AST compared to the FG.

Table 1: Means and SD for phase I traction variables (p-values refer to repeated measures ANOVA)

Shoe	Running Time [s] SLA (p<0.01)	Running Time Ranking SLA (p<0.01)	Traction Rating Suitability (p<0.01)	Force Ratio GRF [-] Cutting (p<0.01)	Mechanical HFR [N/s] Cutting (p<0.01)
HG	10.732 ± 0.651	1.80 ± 0.95	3.20 ± 1.15	0.377 ± 0.151	2981.9 ± 526.2
FG	10.804 ± 0.672	2.50 ± 0.76	3.85 ± 1.42	0.360 ± 0.160	3544.1 ± 335.2
SG	11.027 ± 0.674	3.85 ± 0.37	6.75 ± 1.48	0.305 ± 0.124	4771.3 ± 844.3
ID	10.736 ± 0.699	1.85 ± 0.88	2.25 ± 1.62	0.410 ± 0.139	3100.3 ± 842.5

Results of phase II did not discriminate as clearly between the four shoe conditions as displayed for phase I. The ID shoe condition from phase I was slightly outperformed by the new modified ID shoe conditions. It was shown that the DuoCell design is well suited also for the rearfoot.

Conclusion

The findings of this project allow to state solid construction recommendations for AST shoes. Current AST surfaces call for a reconsideration of the established outsole concepts that were designed for playing on natural grass. Relatively short studs, evenly positioned across the whole forefoot and rearfoot outsole characterize our guidelines for an AST traction design (Figure 1b). Addressing methodological aspects of this project, subject testing procedures were shown to be a discriminative measure between shoes as long as construction features differ relatively strong. When outsole configurations become rather similar and differ only marginally, e.g. in stud hardness, interindividual and intraindividual movement variability does not allow to detect potential functional differences between shoes. The combined use of subject and mechanical testing procedures again provided a systematic strategy to create functional footwear.

Finally, it should be noted that a follow-up competition test (phase III) revealed better traction functionality of the newly created outsole design compared to three current AST shoes on the market from different brands, including the own one. Thereby, the success of the project was confirmed.

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