THE INFLUENCE OF DIFFERENT SHOE MODELS AND THE TRIAL NUMBER ON SPRINTING PERFORMANCE IN SOCCER SHOE TESTING. A PILOT STUDY.

Markus Huthöfer[1], Lara Leutgeb[1], Thomas Finkenzeller[1] and Hermann Schwameder[1]

Department of Sport and Exercise Science, University of Salzburg, Austria[1]

Testing and improving soccer shoe models is important because of the physical demands of the sport. However, sprint-specific activities can also influence sprint performance. The purpose of this study was to identify the effect of different soccer shoe models and the trial number on sprinting and agility performance. Twenty-five soccer players completed four straight-line 30m sprints followed by four change-of-direction (COD) sprints and after each sprint the shoe model was quasi-randomized changed. For straight-line sprinting, horizontal force-velocity-profiling parameters and sprint times were computed and, in the COD-test, sprint time was measured. The results indicate that the trial number affects the ability to generate horizontal force more at higher sprinting velocities than at low sprinting velocities, resulting in nonsystematic variance in the shoe model analysis.

KEYWORDS: force-velocity-profiling, sprint testing, fatigue.

INTRODUCTION: Soccer players change running speed every four seconds (Krustrup et al., 2005; Mohr et al., 2003) and perform numerous explosive movements, like straight-line sprinting or a change-of-direction (COD) sprint (Stølen et al., 2005). These are frequent actions before assisting or scoring a goal (Faude et al., 2012). Therefore, the interaction of shoe and ground in terms of optimal force transfer plays an essential role for optimal sprint performance. Moreover, soccer players chose stability and traction as the second and third most important parameters after comfort (Hennig & Sterzing, 2010). So, the demands on soccer shoes are very high.

A series of studies show that different shoe conditions affect sprinting times (Sterzing et al., 2009). Here, the sprinting ability has been measured purely by sprint times. However, sprint performance can be better characterized by an additional analysis of the mechanical properties of the sprint via horizontal power-force-velocity (P-F-v) profiling, than only reporting the sprinting times (Buchheit et al., 2014; Samozino et al., 2016). This can provide further information on a possible shoe-relevant influence, for example on the initial acceleration or the maximal sprinting velocity.

It has been shown that sprint-specific activities (e.g., repeated sprint testing or a soccer match) can independently influence sprint times and power-force-velocity parameters (Hermosilla-Palma et al., 2022; Huthöfer et al., 2020; Nagahara et al., 2016). In testing soccer shoes this problem should be solved by performing sprints with different shoe models in a randomized order. Especially when comparing a large number of shoes, an activity-related effect might occur. Thus, it is possible that the sprint-specific influence due to the respective sprint trial number may be greater than the influence of different soccer shoes. So, the question may arise whether the sprint test itself causes problems for the evaluation of the shoe models.

So far, it has been shown that parameters and sprint times change individually due to different running and sprinting activities, but this has not yet been investigated over the course of a soccer shoe testing. However, this information is important for the conception of a soccer shoe test, e.g., for determining the sprint distance and the number of sprints as well as for the analysis and interpretation of the results.

Therefore, the aim of this study was to investigate the influence of different soccer shoe models and the trial number on sprint and agility performance in soccer shoe testing.

METHODS: Twenty-five male amateur soccer players (age: 21.8 ± 3.8 yrs; height: 178.1 ± 3.8 cm; mass: 74.1 ± 7.8 kg) participated in the study. The testing took place in summer 2022 and all participants signed an informed consent. Prior to testing, all participants completed a standardized warm-up. The experimental protocol consisted of four 30m sprint measurements, followed by four COD sprints with four different soccer shoes. A three to four minute rest between each sprint was provided (Haugen et al., 2019). For the straight-line 30m sprint, athletes were recorded using a laser distance measurement system (LDM 301, Jenoptik, Jena, Germany; 100 Hz) to calculate theoretical maximal sprinting velocity (V0), theoretical maximal horizontal force ($F0_{rel}$), maximal horizontal sprinting power ($Pmax_{rel}$) ("rel" refers to normalization to body mass), and 10m-, 20m-, and 30m sprint times according to Samozino et al. (2016). The arrowhead agility test was used as COD-test. The COD-times were measured with double beam photocells (Witty Gate, Microgate, Italy).
Every participant had shoe size UK 8.5 as required by the shoe samples available. The sequence of the shoe models was quasi-randomized. The first participant conducted the 30m sprint with shoe model A, followed by B, C and D and afterwards he performed the COD test with the same shoe order. The second participant started the sprint test with shoe model B, followed by C, D and A. The third participant used the order C, D, A and B, and the fourth D, A, B and C. The fifth player started again with the order of the first, the sixth with the order of the second, the seventh with the order of the third and the eighth with the order of the fourth and so on. This procedure of quasi-randomized order was applied to all further participants.
Two one-way ANOVAs with repeated measures were used to test the effects of different shoe models and trial number for the parameters V0, $F0_{rel}$, $Pmax_{rel}$, 10m-, 20m-, 30m and COD-time. In case of global significance, Bonferroni corrected post hoc tests were applied. Effect size was determined by partial eta squared (η^2) with the limits for the size of the effects .01 (small), .06 (medium) and .14 (large). The level of significance was set at $p < .05$. Normal distribution and variance homogeneity were consistently given.

RESULTS: The ANOVA showed no effects regarding the different shoe models. For trial number large effects for 10m, 20m and 30m time, V0, and $Pmax_{rel}$ were found, while no effects for $F0_{rel}$ and COD-time have been observed (Figure 1). Due to space limitations, figures of non-significant parameters have been omitted. The post-hoc analyses revealed differences in most pairwise comparisons for the 10m-, 20m-, 30m time, V0, and $Pmax_{rel}$.

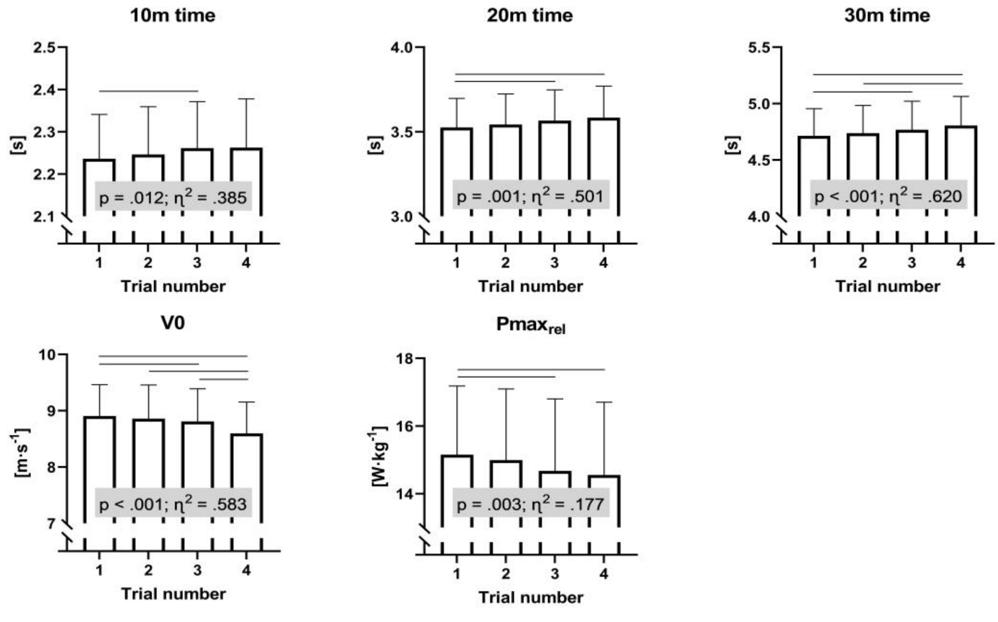

Figure 1: **The results of the ANOVA and post hoc tests for 10m-, 20m-, 30m time, V0 and $Pmax_{rel}$. p = significance level of main effect; η^2 = effect size; Horizontal lines indicate significant differences between pairs.**

DISCUSSION: The aim of this study was to clarify the influence of the different shoe models and the trial number on sprinting and agility performance in soccer shoe testing.
The results of the ANOVA showed no effects for the different shoe models. Sterzing et al. (2009), however, found differences between two shoe models for COD-time, but not for the 6m time, which is very closely related to $F0_{rel}$ or the 10m time. In the study of Sterzing et al. (2009), the significant difference between two shoe models was about 3% in COD-time. Here, one shoe model was made for artificial turf and the other for natural grass. In this study, only soccer shoes recommended for firm surfaces were used, regardless of artificial or natural turf, which is why the shoes used here are probably more similar. Another reason for different findings could have been the use of different COD tests. In the functional traction course of Sterzing et al. (2009) more CODs are included compared to the arrowhead agility test used here. This possibly highlights shoe differences and traction more strongly. Therefore, these shoe differences do not seem to make a difference in parameters for straight-line accelerations (e.g., $F0_{rel}$, 6m time, 10m time).
The results of the ANOVA showed no effects regarding trial number for $F0_{rel}$ and COD-time. But a significant effect of trial number was found for 10m, 20m, and 30m time, V0, and $Pmax_{rel}$, where the initial trials were consistently better. Consequently, the trial number of the shoe model during testing shows large effects regarding the velocity-related parameters.
To the best of the authors' knowledge, no study investigated the activity-related effects of the sprints in relation to the influence of the shoe model. Previous studies, however, have examined the course of F-v-P parameters during different sprint- or soccer-specific activities and these results are very similar to those of the current study. Nagahara et al. (2016) and Huthöfer et al. (2020) observed F-v-P parameters over the course of a soccer game and V0, $Pmax_{rel}$, and 20m time displayed activity-related impairments and $F0_{rel}$ did not. Of course, it can be discussed how great the similarities are between sprint testing and a soccer game, but also a recent study of Hermosilla-Palma et al. (2022) demonstrated similar results. There, professional soccer players performed eight 30m repeated sprints. The results of the ANOVA showed deteriorations with large effects for 30m time ($p<.001$), V0 ($p<.001$), $Pmax_{rel}$ ($p<.001$) and not for $F0_{rel}$ ($p>.05$). Hermosilla-Palma et al. (2022) concluded that some parameters in sprinting are more sensitive to processes of fatigue, which is quantified as the decrease in the ability of muscles to produce maximum force or power (Enoka & Duchateau, 2008). Thus, it appears that sprinting itself has no counterproductive effects on parameters, where initial acceleration is essential, e.g., $F0_{rel}$ and COD-time. It seems, however, that sprint trials result in negative effects on parameters involving higher sprint velocities, e.g., 30m time and V0.
Consequently, the objective for shoe testing must be to create a test concept that is as robust as possible and independent of external influences. Therefore, it is recommended to be cautious when collecting and analysing parameters that have shown an influence on trial number, since a higher number of trials amplifies the unsystematic variance. For example, no statement can be made about the effect on the maximal sprinting velocity of a shoe model, because the unsystematic variance due to fatigue is too high. In the high-speed phase, the ground contact time for the force transfer from shoe to ground is very short, so the shoe model could theoretically have an influence. In contrast, for the more acceleration-oriented parameters, more trials can be planned to figure out a possible systematic variance of different shoe models.
Therefore, for sprint and soccer shoe testing, it is recommended to conduct two sprints with a longer distance (e.g., 30m) and a high-velocity component. Several sprints, however, with a mainly acceleration component can be performed afterwards (e.g., 6m sprints or short CODs like the arrowhead-agility-test). As a consequence, the number of shoes to be compared, must also be considered, as this again affects the number of sprints.
Furthermore, it must be considered that this is a pilot study. It would have been superior if each athlete had sprinted with each shoe at each trial number, but this would have required 16 sprints in total spread over several days causing time-related uncertainties.
Moreover, investigations on different rest times, e.g., longer than four minutes, could yield valuable information.

CONCLUSION: This study provides new insights into the influence of shoe model and trial number in sprint and agility testing of soccer shoes. The results of the ANOVA showed no effects for shoe model, but large effects for the trial number in the more speed related parameters. So, there was an impact on which trial the respective shoe was used for, which increased the undesirable unsystematic variance for the shoe model data analysis. Furthermore, it seemed that the load of the multiple sprint trials had a greater impact on the higher velocity sprinting segment than on the lower velocity sprinting segments. Consequently, the effects of the shoe models on the higher velocity parameters were undetectable due to the unsystematic variance that occurred. As a consequence, this information is important to optimize soccer shoe tests, e.g., the number of sprints and sprint distances. Therefore, the unsystematic variance can be minimized in the future and shoe models can be compared better.

REFERENCES

Buchheit, M., Samozino, P., Glynn, J. A., Michael, B. S., Al Haddad, H., Mendez-Villanueva, A., & Morin, J. B. (2014). Mechanical determinants of acceleration and maximal sprinting speed in highly trained young soccer players. *Journal of Sports Sciences, 32*(20), 1906-1913. doi:10.1080/02640414.2014.965191

Enoka, R. M., & Duchateau, J. (2008). Muscle fatigue: what, why and how it influences muscle function. *The Journal of physiology, 586*(1), 11-23.

Faude, O., Koch, T., & Meyer, T. (2012). Straight sprinting is the most frequent action in goal situations in professional football. *Journal of Sports Sciences, 30*(7), 625-631. doi:10.1080/02640414.2012.665940

Haugen, T., Seiler, S., Sandbakk, Ø., & Tønnessen, E. (2019). The Training and Development of Elite Sprint Performance: an Integration of Scientific and Best Practice Literature. *Sports Medicine - Open, 5*(1), 44. doi:10.1186/s40798-019-0221-0

Hennig, E. M., & Sterzing, T. (2010). The influence of soccer shoe design on playing performance: a series of biomechanical studies. *Footwear Science, 2*(1), 3-11.

Hermosilla-Palma, F., Loro-Ferrer, J. F., Merino-Muñoz, P., Gómez-Álvarez, N., Bustamante-Garrido, A., Cerda-Kohler, H., Portes-Junior, M., & Aedo-Muñoz, E. (2022). Changes in the Mechanical Properties of the Horizontal Force-Velocity Profile during a Repeated Sprint Test in Professional Soccer Players. *International Journal of Environmental Research and Public Health, 20*(1), 704.

Huthöfer, M., Harbour, E., Schwameder, H., & Kröll, J. (2020). Sprint mechanical properties of professional soccer players during a match simulation. *ISBS Proceedings Archive, 38*(1), 748.

Krustrup, P., Mohr, M., Ellingsgaard, H., & Bangsbo, J. (2005). Physical demands during an elite female soccer game: importance of training status. *Medicine & Science in Sports & Exercise, 37*(7), 1242-1248.

Mohr, M., Krustrup, P., & Bangsbo, J. (2003). Match performance of high-standard soccer players with special reference to development of fatigue. *Journal of Sports Sciences, 21(7),.519-528*.

Morin, J.-B., & Samozino, P. (2016). Interpreting Power-Force-Velocity Profiles for Individualized and Specific Training. *International Journal of Sports Physiology and Performance, 11*(2), 267-272. doi:10.1123/ijspp.2015-0638

Nagahara, R., Morin, J.-B., & Koido, M. (2016). Impairment of Sprint Mechanical Properties in an Actual Soccer Match: A Pilot Study. *International Journal of Sports Physiology and Performance, 11*(7), 893-898.

Samozino, P., Rabita, G., Dorel, S., Slawinski, J., Peyrot, N., Saez de Villarreal, E., & Morin, J. B. (2016). A simple method for measuring power, force, velocity properties, and mechanical effectiveness in sprint running. *Scandinavian Journal of Medicine & Science in Sports, 26*(6), 648-658. doi:10.1111/sms.12490

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, 1*(1), 5-17.

Stølen, T., Chamari, K., Castagna, C., & Wisløff, U. (2005). Physiology of soccer: an update. *Sports medicine, 35*, 501-536.