IN-SHOE PLANTAR PRESSURE MEASUREMENTS DURING GOLF SWING PERFORMANCE WEARING METAL AND ALTERNATIVE SPIKED GOLF SHOES

Paul Worsfold[*], Neal Smith and Rosemary Dyson.

***University of Chester, Chester, Cheshire, UK**
University of Chichester, Chichester, West Sussex. UK.

In-shoe plantar pressures were assessed when two different golf shoes were worn. One shoe design incorporated 7 metal spikes and the other 7 alternative spikes. Eighteen male golfers (mean handicap ±SD: 12.4 ± 7.8) played 5 shots with a 7 iron while wearing each shoe on a natural grass surface. Pressures in 9 standardised foot regions were analysed to yield maximal, average and ball impact values. The greatest pressures were at the lateral regions of the front-foot from the point of ball impact when wearing the metal spike shoes. Significantly greater maximal pressures occurred when wearing the metal spike shoe (front foot: lateral 114 kPa; back foot: lateral heel 40 kPa, medial central 63 kPa; $p<0.05$). In the alternative spike shoe, significantly greater maximal (76 kPa) and average pressures (41 kPa) occurred on the back foot at the central toe region.

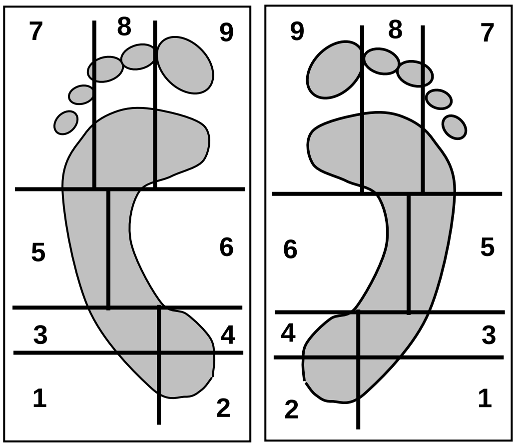
KEY WORDS: Footwear, golf, pressure, shoe, spike.

INTRODUCTION: Previous ground reaction force studies (Worsfold *et al*., 2006, 2007) have identified the forces, torques and interactions between the golf shoe sole interface and a natural turf ground surface. To further assess the functional properties of golf shoe interfaces, an understanding of the shoe-foot interaction is required. McPoil & Cornwall, (1995) stated that in-shoe pressure measurements can provide a greater understanding of the effects of specialised footwear, as well as assist in their modification to maximise their benefit to the user. Wallace *et al*., (1994) reported foot pressures during the golf swing of six right-handed male golfers wearing two types of shoe, one with metal spikes on the outer sole, and another with a rubber moulded sole. The golfers played shots with their own driver off a grass-covered tee-box outdoors while wearing shoes containing eight piezo-electric film transducers sampled at 400 Hz. The limited understanding of the relationship between within shoe plantar pressures and golf shoe sole traction designs does not allow prediction of the effects of modified golf shoe design features such as alternative spikes. Alternative spikes have been introduced in response to concerns about the damage to golf courses by metal spike shoes (Hammond & Baker, 2002). This research analysed, during the golf swing, in-shoe pressures to identify any plantar pressure differences associated with the wearing of a golf shoe fitted with metal spikes compared to a golf shoe fitted with alternative spikes.

METHODS: Eighteen right-handed male (mean ±SD age: 29 ± 2.2 years; mass: 81.4 ± 2.8 kg; height: 179.9 ± 1.9 cm) golfers volunteered for the study. The golfers' handicaps ranged between 24 and for the better golfers 0 (mean 12.4 ± 7.8). Two types of golf shoes with identical uppers but different sole interface designs were tested. One shoe incorporated alternative spikes (Figure 1A), and one metal spikes (Figure 1B), with seven spikes in total on both shoes in similar locations on the shoe sole

Figure 1: Golf shoe alternative spike (A) and metal spike (B) fitted to improve traction

Plantar pressure insoles (Footscan RSscan International, Belgium) were fitted inside both left and right shoes. The shoe insole size was selected to fit comfortably within each individual's shoe. Subjects were given time (walking and playing shots) to become accustomed to wearing the shoe and insole combination. Five shots were played on a natural turf surface with the subject's own 7-iron while wearing each shoe type. The order of shoe testing was randomized for each participant. A Footscan data logger was attached to the back of the golfer's waist to prevent any movement restrictions. During each golf swing, data from the insoles within the front foot (closest to the direction of the shot), and the back foot were recorded by the data logger for 8 seconds with sampling at 500Hz. Foot movements and ball impact were captured using a 200 Hz High Speed Peak Systems Camera (Peak Performance Technologies inc. Englewood, Colorado USA).



Analysis involved the setting of nine plantar foot regions using the dynamic regional analysis feature, which adapted for individual foot size and form by screening the foot from different directions. The Footscan software (version 2.33) placed a mask on top of the footprint which divided it into nine regions, which were proportional for foot length and width (Figure 2). Maximum pressure, average pressures during the whole swing process and pressures at ball impact were analysed for the nine regions of both the left and right feet. Mean and standard deviation values were calculated for all data. One way analysis of variance with repeated measures and a Tukey HSD post hoc test were applied.

Figure 2: The left (front) and the right (back) foot dynamic regional analysis identifying the nine foot regions (R1-R9)

RESULTS:

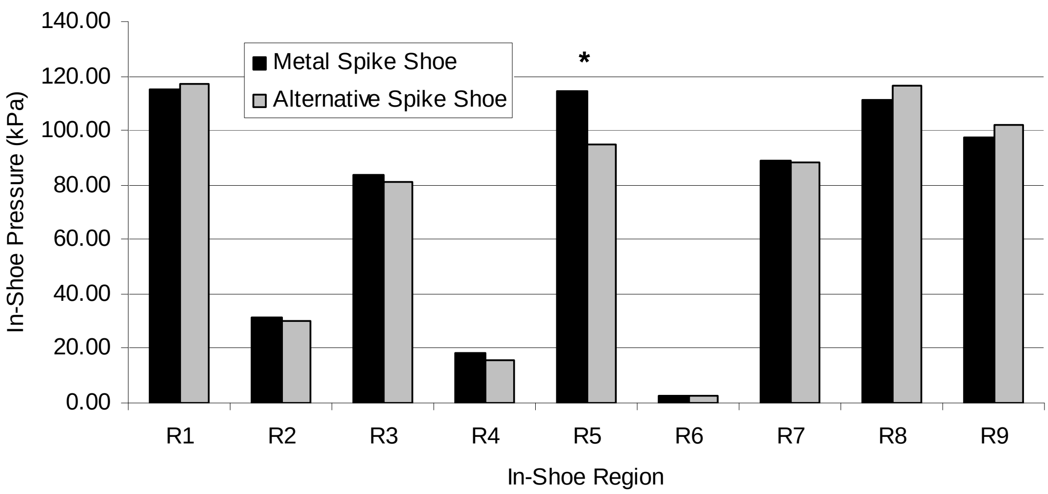


Figure 3: **Front-foot maximum pressures during the whole swing process when using a 7-iron.**
Note: * Denotes significant difference between shoes $p<0.05$.

In-shoe pressure analysis identified that wearing the metal spike shoe was associated with significantly greater ($p<0.05$) maximal plantar pressure at R5 (mid-lateral) of the front-foot and at ball impact (Figures 3 & 4). At the back-foot the metal spike shoe was associated with the production of significantly greater ($p<0.05$) maximal and average in-shoe pressures at the mid-medial arch position R6 (Figure 5). Significantly greater ($p<0.05$) metal spike maximal pressures were also identified at R1 at the outer heel of the back-foot. The alternative spike shoe was associated with significantly greater ($p<0.05$) maximal and average pressures at R8 (mid toe region) of the back-foot (Figure 6). Average pressures at the front foot were similar for both shoes.

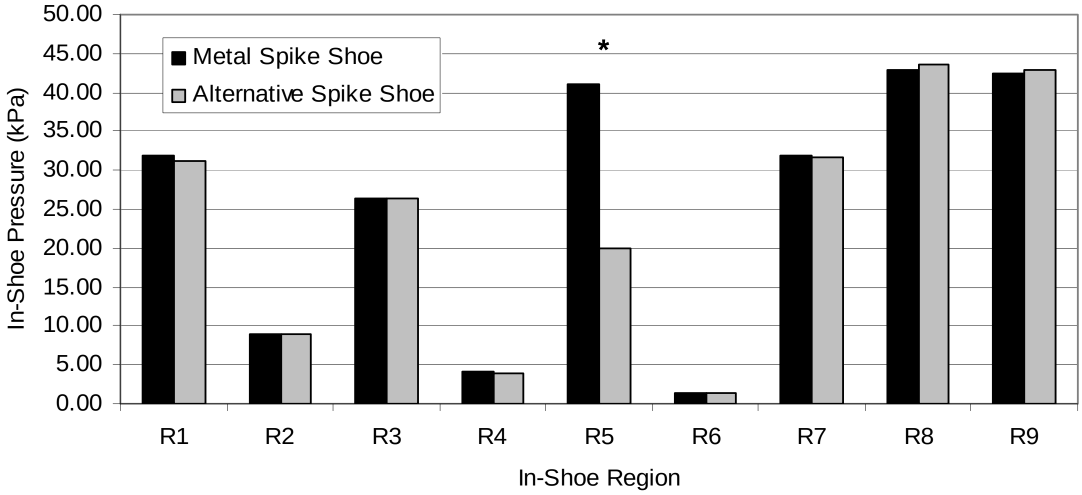


Figure 4: Front foot maximal pressures at time of ball impact when using 7-iron
Note: * Denotes significant difference between shoes $p<0.05$.

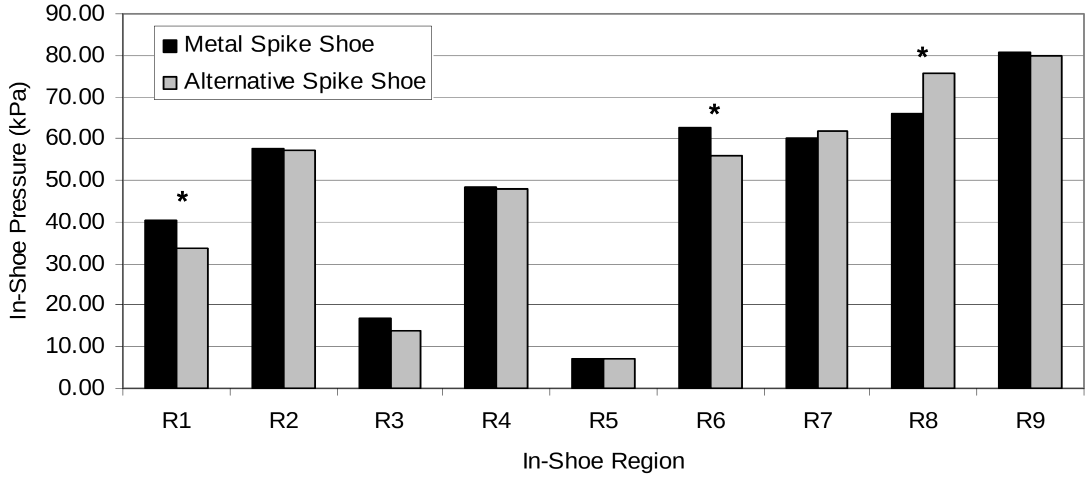


Figure 5: Back foot maximum pressure during the whole swing process when using 7-iron.
Note: * Denotes significant difference between shoes $p<0.05$.

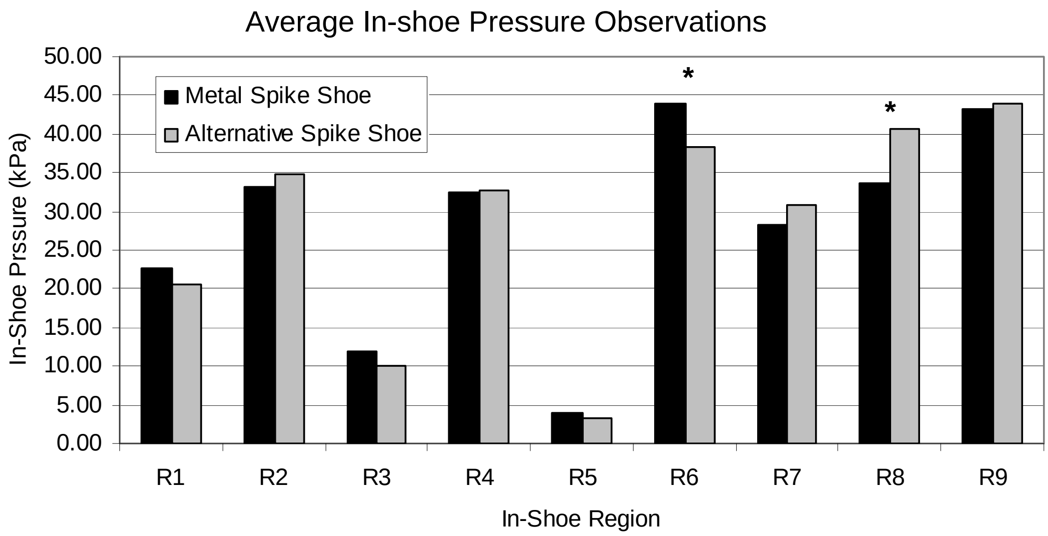


Figure 6: **Back foot average pressures during the whole swing process when using 7-iron**
Note: * Denotes significant difference between shoes $p<0.05$.

DISCUSSION: Pressures of up to 120 kPa were recorded inside the front foot shoe, while maximal pressures at the back foot peaked at approximately 80 kPa. These findings are in general accord with previous research (Worsfold *et al.*, 2007) which identified greater

maximal vertical ground reaction force with the 7-iron at he front foot (1.1BW) than the back foot (0.82 BW), and the within shoe pressure study of Wallace *et al.* (1994). Significant differences in the pressures recorded under both the front and back feet within the shoe linked to shoe design outer sole features. At the front foot shoe the greatest pressures occurred at the lateral heel, lateral side of the foot and at the 1st, 2nd and 3rd metatarsals. The finding of the greatest maximal pressures at the 1st metatarsal in the metal spike shoe was in accord with earlier research reported by Wallace *et al.* (1994). The maximal pressure on the lateral side of the front foot was greater by 18% in the metal spike shoe, and at ball impact the pressure on the lateral side of the front foot was twice as great in the metal spike shoe compared to the alternative spike shoe (Figure 4). Such large significant differences identified during this experiment, when good front foot shoe traction was important to allow the club and body to decelerate around the front leg at impact and in the follow-through, lend support to the concept (e.g. Frederick, 1986) of human perception influencing physical muscular performance and foot action.
The alternative spike shoe was associated, notably, with the production of significantly greater maximal pressure over the back foot 2nd and 3rd metatarsal (R8, Figure 5), which was supported by average pressure analysis (Figure 6). This region was important during weight transfer at impact and in the follow-through when the back foot heel raised and stance stability was dependent on good forefoot traction.

CONCLUSION: Shoe design features on the outer sole of the golf shoe influence within shoe plantar pressures, and thus must be perceived by the player who adapts muscular control of the body and lower extremity during the golf swing. Such findings lend support to the concept (e.g. Frederick, 1986) of human perception influencing physical muscular performance and foot action. The importance of ensuring players familiarise with sporting tasks while wearing appropriate performance footwear was supported.

REFERENCES:

Hammond, L.K.F. & Baker, S.W. (2002). The effect of metal and alternative golf spikes on visual turf quality and playing characteristics of Fustuca Rubra/Agrostis Capillaries/Poa Annua putting surfaces. *Journal of Turfgrass and Sports Surface Science,* 76, 46-58.

Frederick, E.C. (1986). Kinematically mediated effect of sport shoe design: a review. *Journal of Sports Sciences,* 4, 169-184.

McPoil, T., Cornwall, M., & Yamada, W., (1995). A comparison of two in-shoe plantar pressure measurement systems. *Lower Extremity,* 95-103.

Wallace, E., Grimshaw, P., & Ashford, R. (1994). Discrete pressure profiles of the feet and weight transfer patterns during the golf swing. In *Science and Golf II. Proceedings of the World Scientific Congress of Golf.* (Ed. Cochran, A.J. and Farrally, M.R.). E and FN Spon. p.27-32.

Worsfold, P.R., Smith. N.A. & Dyson, R. (2006). Force generation at the golf shoe sole to grass turf interface occurring with alternative spike designs. In *Proceedings of XXIV International Symposium on Biomechanics in Sports* (Ed: Schwameder H, Strutzenberger G, Fastenbauer V, Lindinger S, Muller, E.). Austria: University of Salzburg p.502 – 505.

Worsfold, P., Smith. N.A. & Dyson, R.J. (2007). A comparison of golf shoe designs highlights greater ground reaction forces with shorter irons. *Journal of Sports Science and Medicine.* 6, 484-489

Acknowledgement
Footwear for this research was provided by Adidas and financial support from University of Chester.