INFLUENCE OF THE FOOTBALL BOOT DESIGN ON SHOCK ABSORPTION

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INTRODUCTION

Shock absorption or reduction is a general criterion for sports footwear design, although its relative importance depends on the particular characteristics of each sport. In general, impacts are produced whenever there is a sudden deceleration of the body mass, such is the case of running, jumping and even walking race. In football, due to the field dimensions and to the game characteristics, running is one of the most frequent movements. And, added to the running pattern, the fact that there are studs and there is not midsole causes frequent and high level impacts.

There is experimental evidence of a possible correlation between repetitive impacts and the development of degenerative musculo-skeletal diseases, specially relating the articular cartilage (Radin, 1980; 1987; Broom, 1986). To attenuate such impacts, the human body possesses a number of natural shock absorbing mechanisms, including the heel pad and the articular cartilage effect and the mobility of joints. These mechanisms attenuate between 50 and 90% of the impacts at knee level (Cavanagh, 1984; Wosk, 1981) and up to 98% at head level (Light, 1980; Wosk, 1981; Wosk, 1982)

During recent years, studies have been published on the importance of footwear design with relation to preventing injuries (Masson, 1989; Stacoff, 1988). Some epidemiological studies show that football is characterized by a high numer of injuries (Hoff, 1986; Ydes, 1990). Football practice involves frequent running and jumping movements (Reilly, 1976), being shock absorption a basic criterion for the design of footwear intended for sports involving these movements. To improve the shock absorbing ability of sports footwear, two strategies are often followed: to potentiate the natural shock absorbing mechanisms or to supplement these by an appropriate selection of sole and insole materials.

The purpose of the study was to investigate the effect that different boot designs and different sole and insole materials had on impact transmission during running.

METHODS

According to a previous study on materials, three boot prototypes and four insole prototypes were made. Eight healthy football players were selected. They performed 6 runs with each of the twelve boot/insole combinations. The runs were performed in a football field and the speed was fixed at 4 m/s, being controlled by means of two photoelectric cells connected to a chronometer. The run speeds between 3.6 and 4.4 m/s were regarded as valid. The order was randomized for each subject.

The subjects were instrumented with two ICESENSORS accelerometers, with a weight of 0.3 g, which were placed on the skin by means of a thight bandage, one on the proximal third of the tibia and another on the central area of the forehead. The signal of the accelerometers were connected to a JOHNE REILHOFFER telemetric equipment, which was placed in a rucksack carried by the subject, and which sent the signal to a computer. This allowed the subject for free movements.

The signals obtained were similar to those showed in figure 1. For the statistical analysis of each impact the following parameters were selected:

ATG: acceleration peak in tibia, corresponding to heel impact.

ACG:: acceleration peak in forehead, corresponding to heel impact

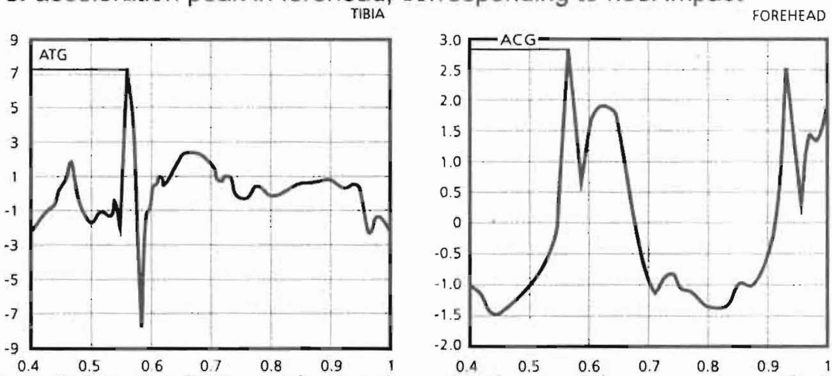

Figure 1: Signals of tibia and forehead accelerations and the parameters selected for the study.

With the parameters obtained, an Analysis of Variance (ANOVA) was made with each of these variables, being the factors: subject, boot and insole. $\alpha<0.05$ was chosen as a priori level of significance. To analyse the differences between conditions, an LSD test (Lower Significant Differences) was made.

RESULTS

As expected, the acceleration values found both in tibia and forehead were high, being mean acceleration 6.01 g in tibia and 2.45 g in forehead. These results confirm the hypothesis that shock absorption is an important criterion for football footwear with relation to prevention of injuries.

Table 1 show the results for acceleration in tibia and forehead obtained with the insoles tested. The statistical analysis show statistically significant differences for acceleration in tibia -ATG- ($p=0.02$); however, for the acceleration in forehead -ACG- the differences were not statistically significant ($p=0.23$). The LSD test for ATG showed differences between the insoles with M2 inserts, with lower values for acceleration in tibia in comparison with the others. This material showed a lower rigidity in the previous studies for the selection of materials, performed using a testing machine. It is important to note that the significance level for the interactions subject/insole was of $p=0.06$, which indicates that the results obtained with the insoles would not be the same for all subjects.

INSOLE	ATG (G)	ACG(G)
M1	6.09±0.13	2.45±0.03
M2	5.67±0.13	2.395±0.03
M3	6.08±0.13	2.48±0.03
M4	6.20±0.13	2.49±0.03

Table 1: Mean values of acceleration in tibia (ATG) and forehead (ACG) for the insoles tested.

In table 2 there are shown the results for acceleration in tibia and in forehead with the boots tested. The statistical analysis showed statistically significant differences for the acceleration in tibia ($p=0.02$). For the acceleration in forehead, though the differences were not statistically significant ($p=0.06$), the proximity to the level of significance chosen a priori could indicate the existence of real differences. For acceleration in tibia, the LSD test showed differences between boots 1 and 2 respect boot 3, being the level of acceleration in both cases (tibia and forehead) lower for the two first. It is important to note that, according to the previous studies for the selection of materials, the type of sole of boots 1 and 2 was that with higher rigidity and lower ability to dissipate energy. The disparity of results found between tests with subjects and with machines could indicate that the interaction of the studs with the ground can cause unexpected effects of shock absorption not detectable in the tests with machines.

BOOT	ATG(G)	ACG(G)
1	5.91±0.11	2.46±0.03
2	5.86±0.11	2.40±0.03
3	6.26±0.11	2.50±0.03

Table 2: Results obtained for acceleration in tibia (ATG) and forehead (ACG) with the insoles tested

CONCLUSIONS

The results obtained for the insoles indicate that the insertions of M2 are the most effective in the resuction of impacts of all those analyzed, with an average reduction of impacts near 6% in tibia. With relation to the boots studied, 1 and 2 showed a grater shock absorbing ability, about 7%. Although a diminishing in impacts can be noted, both in tibia and forehead, with boot 2 with respect to boot 1, these differences are not statistically significant. The difference between the boots was merely in the strength of the heel counter, so this result could indicate that by improving the design it can be possible to improve the boots' shock aborption, confining the heel pad. This fact is to be proven by more studies centered in heel counter of football boots. According to the results, an appropriate combination of insole materials and boot design, an improvement in shock absorption of 13% can be achieved.

Note that, even though the tests were made on a natural grass football field and that run speed was not very high, the values found both for tibia and forehead were high; this fact confirms the hypothesis that shock absorption is a basic criteria for the design of football boots if the prevention of injuries is considered.

REFERENCES

Broom N.D. (1986). Structural consequences of traumatising arthicular cartilage. Ann Rheum. Dis. 45, 225-234.

Cavanagh, P.R.; Valiant, G.A.; Misevich, K.W. (1984) Biological aspects of modeling shoe/foot interaction during running. Frederick E. C. Sport Shoes and Playing Surfaces. Human Kinetics Publishers, Champagne I.L.

Hoff, G.L and Martin, T.A. (1986). Outdoor and Indoor soccer: Injuries among youth players. *Am. J. Sp. Med.* **8**, 231-233.

Light, L.H.; McLellan, G.E.; Klenerman, L. (1980). Skeletal transients on heel strike in normal walking with different footwear. J. Biomech. 13, 477-480.

Masson, M. and Hess, H. (1989). Typical soccer injuries. Their effects on the design of the athletic shoe. In B. Segesser & W. Pförringer (Eds.) *The shoe in sport*. London: Wolfe Publishing, Ltd., 89-95.

Radin, E.L.; Paul, I.L.; Rose, R.M. (1980). Ostheoarthrosis as a final common pathway. The aethiopathogenesis of osteoarthrosis (pp 84-89). Nuki G. (ed). Turnbridge Wells: Pitman Medical.

Radin, E.L. (1987). Osteoarthrosis: what is known about prevention. Clin. Orthop. Rel. Res. 222, 60-65.

Reilly, T. (1976) A motion analysis of work rate in differential roles in professional football match play. *J. Human Mov. Stud.* **2**, 87-97.

Stacoff, A.; Denoth, J.; Kaelin, X. and Stuessi, E. (1988). Running injuries and shoe construction: Some possible relantionships. *Int. J. Sports Biomech.* **4**, 342-357.

Wosk, A.; Voloshin, A.S. (1981). Wave attenuation in skeletons of young healthy persons. J. Biomech. 14, 261-208.

Wosk, A.; Voloshin, A.S. (1982). Force wave transmission through the human locomotor system. J. Biomech. 15, 21-27.

Yde, J. and Nielsen, A.B. (1990). Sport injuries in adolescents'ball games: soccer, handball and basketball. Br. J. Sp. Med. 24(1), 51-54.