APPLICATION OF BIOMECHANICS TO THE PREVENTION OF OVERLOAD INJURIES IN ELITE SOCCER PLAYERS.

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Structural alterations of the foot and inadequate design of sports footwear, as well as overtraining, have been determined to be risk factors for overload injuries during sports practice. A biomechanical analysis protocol was designed to study both, the foot and sports footwear statically and dynamically. This protocol was applied on 47 soccer players of the Spanish Premier League. Amongst the results we should point out that 53.3% of the players had cavus feet. 14.8% of the players deformed the boots. 44.7% of the players studied registered high pressures over the metatarsal heads, and 19.1% registered high ones at the first toe. 44.7% of the players showed an excessive supination pattern. The data obtained gave us information about the static and dynamic patterns of the elite soccer player. With the individual information the assessment of suitable footwear was carried out for each player. The correct application of this protocol could be used in the diagnosis or prevention of overtraining and in the detection of foot and gait pathologies.

KEY WORDS: biomechanics, injuries, footwear, soccer, foot, plantar pressures.

INTRODUCTION: During the practice of soccer, high impulsive forces arise, which in some cases can lead to many types of lower limb injuries. There are two types of injuries which often occur common in soccer: traumatic injuries resulting from a single incident and overload injuries resulting from a series of microtrauma. In this study, we will discuss overload type injuries. The origin of the overload injuries in sports remains unclear. Fatigue caused by high intensity training (Ljungqvist & Eriksson, 1982) or by training excesses (Pagliano, 1987) has been indicated as a risk factor of overload injuries in long-distance runners. James *et al.* (1978) and Subotnick (1985) pointed out that one of the main risk factors that causes overload injuries is the mechanical one. Many later studies have been published with the purpose of clarifying the etiology of the overload injuries. The influence of the structural alterations of the foot and of the design of sports footwear on the injuries and on the athlete's efficiency has been studied by the Institute of Biomechanics of Valencia (IBV) during the last 15 years (Brizuela *et al.*, 1997; Ferrandis *et al.*, 1994; Ramiro *et al.*, 1988). The cleats are one of the main characteristics of soccer footwear. They allow the soccer player quicker and more efficient movements over the field (Masson and Hess, 1989; Rodano *et al.*, 1988). Acting over the footwear design and the cleats distribution disorders and injuries can be prevented. In this sense, with the purpose of preventing the frequent injuries caused by mechanical factors on account of structural alterations in the soccer player's feet, or to an inadequate adaptation of the soccer boot, a protocol that would allow to make a static and dynamic analysis of the feet and the sports footwear in soccer was designed. The protocol was applied in various soccer teams at the beginning of the season. A database was prepared with the obtained data. In this way, when some player presented problems during the soccer season, the study could be repeated and the variations in the biomechanical patterns could be analysed. Finally, a reference pattern per soccer player was also established for analysing further in the season to assess fatigue influence.

METHODS: The hard competition schedule of the Spanish Premier League soccer teams and the fact that many of the soccer players belong to the National Teams of other countries revealed two important aspects for this study: 1) an increase of the risk of overload injuries, 2) the players lack of time to be explored and studied adequately.
In order to consider the study as a prevention of injuries, this research was done during the team training camp (preseason). The biomechanical protocol was included in the different explorations done by the medical services of the clubs (along with the blood tests, respiratory and cardiac tests, etc.).

The first part of the study was carried out in the medical installations and took 30 minutes per player. This phase of the protocol was made as follows:
1) *Personal interview with the soccer player.* The study required two teams of researchers. One team made up of doctors and physical therapists, who specialized in the field of biomechanics and pathomechanics of the foot, interviewed the players. The objective of this interview was to detect the pathologies that were closely connected to the use of footwear, specially the repeated injuries in their lower limb and in their foot.
2) *Clinical exploration.* After the interview, a clinical exploration of the lower limb was done, emphasizing the range of motion of the foot and ankle in order to detect possible anomalies including those in connection to the alignment of the lower limb.
3) *Morphological and dimensional analysis of the foot.* An evaluation of the foot dimensions and of its static support was done by means of techniques of image analysis and techniques of dimensional evaluation of the foot (IBV protocols) (IBV, 1994). The morphological analysis of the foot of each player was done by a digital podography (*Fig. 1)*, which provided a file with dimensional information, in a numeric format, about the contour / girth of the plantar footprint in bipedal support. With this purpose a plantar footprint in standing position was registered by a polarized-light podoscope (*Fig.* 2). In order to obtain the dimensional analysis, the podometric protocol of the IBV was applied to obtain the data that the podography did not show (heights, foot perimeters, etc.). The dimensional and morphological analysis of the foot was completed by the registration of the foot on a Footcast, whose digitization allowed us to obtain the relief of the footsole in three dimensions.

Figure 1. Digital Podography

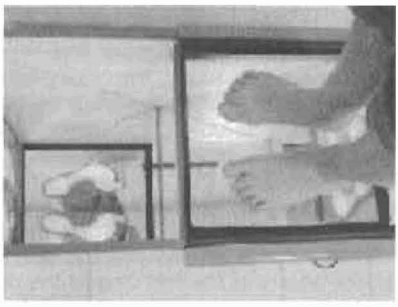

Figure 2. Polarized-light Podoscope

Analysis of footwear deterioration. Each player's footwear was reviewed to detect hints related to the overload injuries suffered by them, such as deformation of the materials and wearing out of the cleats or sole. In the second phase of the study, another group of researchers subjected each player to an analysis of plantar pressures in the soccer field that lasted 30 minutes. The registration and analysis of plantar pressures during the specific movements in soccer and wearing the usual footwear is fundamental to detect the support anomalies, overpressures, and problems with the fitting of the sports footwear. The IBV laboratory has a system of flexible instrumented insoles BIOFOOT/IBV that permits to register the foot pressures inside the shoe and to transmit them by telemetry to the computer while the player is moving freely in the soccer field. For this study, such equipment was used sampling at a frequency of 250 Hz for 3 seconds. The surface of a field of 20 meters long and 3 meters wide was needed (*Fig. 3)*. This test was carried out with the player running at 3 m/sec. Each player wore the boots he was going to use during the competition and training season, as well as the training footwear used for training running at the beginning of the period. Eleven anatomical zones of the foot plant selected for their functional meaning were studied in each player. The statistical treatment included an analysis of variance (ANOVA) with the zone as factor. The significant level was established in $g < 0.05$. Once the protocol finalized, it was carried out to 47 soccer players, which belonged to the Valencia, Villareal and Zaragoza soccer teams. From the obtained data, a personal report of each player was drafted and transferred to the medical services of the respective soccer teams.

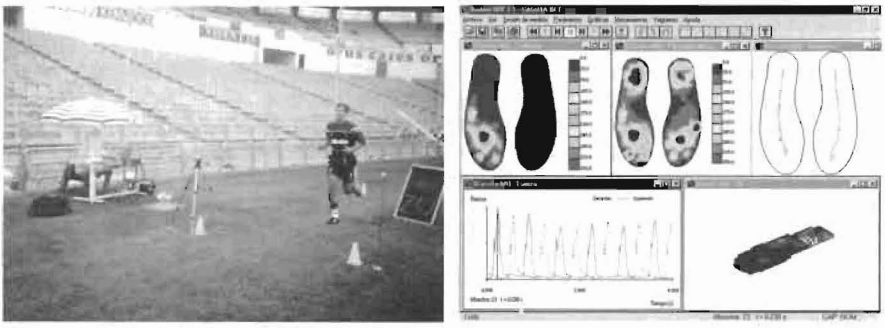

Figure 3. Plantar Pressures Registration and data obtained.

RESULTS AND DISCUSSION: The most interesting results of the study were:
1. After the personal interview and the clinical exploration, it was observed that 25.5% of the soccer players already used special insoles.
2. 27.6% of the players presented some kind of back or lower limb discomfort at the time of the study. This is a high rate if we take into account that all of them had been in a one-month resting period.
3. 25.5% had toenails problems, and 12.8% presented *Hallux Valgus*. Both disorders could be related to the use of too fitted footwear (Doncker *et al.*, 1970).
4. 55.3% of the players had cavus feet, which makes a high rate compared to the average of the population.
The podometrical measurements were compared to the database of the Spanish population. The differences observed were used to give advice to the players regarding appropriate footwear.
The analysis of footwear deterioration showed that 14.8% of the boots became distorted over the external front zone. That could be due to lateral displacements during the play.

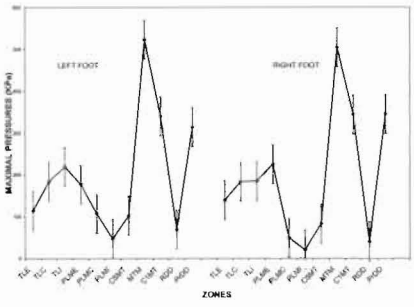

Figure 4. Individual plantar pressures pattern.

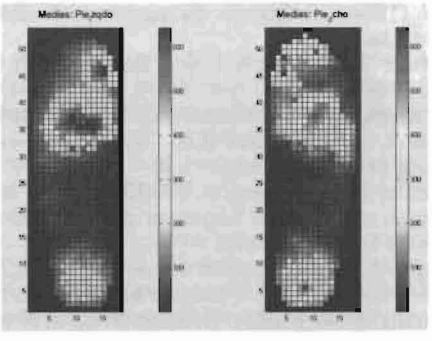

Figure 5. Plantar pressures results.

The second part of the study was the plantar pressure analysis. In a previous research about pressure discomfort threshold on the foot plant (Gonzalez *et al.*, 1999), it was observed that pressures higher than 500Kp over the metatarsal heads caused discomfort. Pressures which were higher than 400Kp over the first toe caused a similar problem. A 44.7% of the soccer players studied registered pressures higher than 500Kp over the metatarsal heads, and a 19.1% registered pressures higher than 400Kp over the first toe. All of them were taken into account in order to prevent injuries (*figures 4 and 5)*. Some abnormality in the foot pronosupination can lead to different lower limb disorders (Messier and Pittala, 1988). That was another factor studied in plantar pressure's research. A 44.7% of the players showed an excessive supination pattern. After the analysis of the static and dynamic data, the

assessment of suitable footwear, cleats distribution and customized insole adaptations were carried out.

CONCLUSIONS: The conclusions reached were:
A method of biomechanical study has been designed; this allows to detect foot alterations as well as inadequate adaptations between the foot and the soccer boot. The whole protocol can be fulfilled in one hour (30 minutes for the static analysis and 30 minutes for the plantar pressure registration).
The data obtained gives information about the static and dynamic patterns of the elite soccer player.
Such information, properly transmitted to the medical services of the clubs can help to prevent overuse injuries.
The data obtained allows footwear adaptation in a customized way. On the other hand the average data provides the industrial sector with design criteria, which allows to improve the soccer footwear.
The study could be repeated in the middle of the season, or when it is suspected that the player is in an overtraining period. Variations in the biomechanical patterns could help in the diagnosis; prevention and treatment of overuse injuries as well as fatigue. That could be an aim to have into account for the future.

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