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ORIGINAL

FOOTPRINT MODIFICATIONS ACCORDING TO THE PHYSICAL ACTIVITY PRACTISED

ALTERACIONES DE LA HUELLA PLANTAR EN FUNCIÓN DE LA ACTIVIDAD FÍSICA REALIZADA

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ABSTRACT

The aim of this paper was (1) to describe the characteristics of the footprint of three groups of women that practise different levels and types of physical activity (sedentary group, elite futsal players and elite hockey players) and (2) to analyse the modifications suffered by their footprints after an intervention period characterised by the sport discipline that they practise. 33 women participated in this study - age: 22.6 ± 3.0, weight: 62.2 ± 7.5 kg, and height: 165.0 ± 5.9 cm -. Five measurements were performed to analyse their type of foot: the Hernández Corvo method, arch index, footprint area, manual measure of navicular height, and tibial-calcaneal angle. These measurements were made twice: at the beginning of the pre-season and at the end of it. According to the Hernández Corvo method, the results showed modifications in the hockey players' footprint, which also tended to flatten. The futsal players only presented modifications in one foot. Sedentary women did not show any footprint modifications. Therefore, this study has proved that continued physical activity causes footprint modifications in those who practise it.

KEY WORDS: photopodogram, arch index, Hernández Corvo method, women futsal, women hockey.

RESUMEN

El objetivo de este trabajo ha sido describir las características de la huella plantar en tres grupos de mujeres con distintos niveles y tipo de actividad física (sedentarias, jugadoras de élite de fútbol sala y hockey hierba) y analizar la evolución del morfotipo de pie tras un período de intervención marcado por la disciplina deportiva que practiquen. Han participado 33 mujeres con unas medias de edad, masa y estatura de 22,6 ± 3,0 años, 62,2 ± 7,5 kg y 165,0 ± 5,9 cm. Se realizaron cinco mediciones para analizar el tipo de pie: método de Hernández Corvo, índice del arco, determinación de la superficie de la huella, medida manual de la altura del escafoides y del ángulo tibio-calcáneo. Estas medidas se tomaron en dos momentos, al inicio y final de la pretemporada. Los resultados demostraron modificaciones en las huellas de las jugadoras de hockey, según el método de Hernández Corvo, con tendencia a aplanarse. En las de fútbol sala sólo se observaron diferencias en un pie. Por el contrario, las sedentarias no presentaron modificación de la huella plantar. Por lo tanto, la actividad deportiva continuada ha provocado modificaciones en la huella plantar de las jugadoras analizadas en este trabajo.

PALABRAS CLAVE: fotopodograma, índice del arco, método Hernández Corvo, fútbol sala femenino, hockey hierba femenino.

INTRODUCTION

The foot, as locomotor structure, is the basis of our body as it is the only contact we have with the surface, it requires special mention. Thus many authors who have studied it. Viladot (2000) states that "the foot is a three dimensional structure variable, antigravity base and is a key position for bipodal and human progress."

Lippert (2005) comments that the human foot is the result of the transformation of the prehensile foot of the monkeys in static foot support. The foot has a function on both static and dynamic (Escobar, 2007; Torrijos et al. 2009). The functionality of the human foot is clearly influenced by its structure (McCrory et al., 1997; Shiang et al. 1998; Menz and Munteanu, 2005) and thanks to the cupular shape (Hernández Corvo, 1989; Kapandji, 1998; Viladot , 2000) of the plantar arch and heel support points and metatarsals, is capable of supporting the entire body weight without sinking. Besides the internal longitudinal arch height influences other body structures, such as the back (Hernández Corvo, 1989; Gómez, 2003; Menz and Munteanu, 2005). The morphological characteristics in the human foot varies somewhat with age (Scott, Menz and

Newcombe, 2007) and between individuals (Cowan, Jones and Robinson, 1993; Shiang et al., 1998; Mayorga-Vega et al., 201 2). These variations are beyond the visual assessment. That is why we have to analyse each individual's feet in detail. For this there are a lot of techniques both direct (x-rays...) and indirect (anthropometry, photopodorgam...). Based on these analyses the type of the height of the navicular to the ground, the Chipaux index, the angle of Clarke (1933) or Feiss line (López et al., 2005) could be some of them. A simple and valid way to analyse the foot is by obtaining the footprint (Shiang et al., 1998). As well as structural variations due to the evolution marked by age, feet exhibit variations in structure due to many factors, such as: the age when you start wearing shoes (Sachithanandam and Joseph, 1995), the age when you begin to play a sport with medium or high dedication (Aydog et al., 2005a; Martin, 2008, Zahínos, González and Salinero, 2010), overweight (Sachithanandam and Joseph, 1995; Hills et al., 2001; Masaun, Dhakshinamoorthy and Parihar, 2009; Vidal et al., 2010), the own repetition of a sport technique, the possible fatigue (Abián et al., 2005), or the fact of playing a sport or even a specific discipline (Sirgo and Aguado, 1991; Sirgo et al., 1997; Aydog et al., 2005a; López et al., 2005, López et al., 2006, Cain et al., 2007; Elvira et al., 2008; Antolinos and Martínez, 2010; González Pérez and Floría, 2012).

The objectives of this study has been: 1) to describe the characteristics of the footprint of three groups of women with different levels and types of physical activity, 2) to analyse the modifications suffered by their footprints after an intervention period characterised by the sport discipline that they practise and 3) to compare several methods of evaluating the footprint described in the literature by Hernández Corvo method (HC), arch index (AI), the height of the navicular bone (AE) and the measurement of the footprint surface (SH) with Autocad 2007.

METHOD

Participants

In this longitudinal study (two measurements: at the beginning and at the end of the preseason) 33 young women have participated, with a mean of age, mass and height of about 23 years (22.6 ± 3), 62.23 ± 7.55 kg and 165 ± 5.9 cm, respectively (Table 1), belonging to three groups, depending on their characteristics:

- The first group consisted of 11 players of futsal (FS), belonging to an elite team (Division de Honor – Women First Division).
- The second group made up by 12 hockey players (HH), members of an elite team (Division de Honor – Women First Division).
- The third group consisted of 10 female sedentary (S) voluntarily participated in the study.

All the participants in this study were informed about the nature of it and volunteered to be part of the research.

Table 1. Characteristics of the participants (FS: futsal; HH: hockey; S: sedentary women)

	FS	HH	S	TOTALS
N	11	12	10	33
AGE	23.2 (±3.28)	21.9 (±3.75)	22.8 (±1.32)	22.6 (±3)
WEIGHT	59.464 (±4.699)	62.5 (±6.32)	64.98 (±10.55)	62.239(±7.55)
HEIGHT	162.4 (±6.36)	166.3 (±5.754)	168 (±4.163)	165.485(±5.87)

Inclusion criterion for the HH and FS group were: be federated in their corresponding sports federation and have been practicing their sport competitively for at least two years (Elvira et al., 2008a). Finally, it was considered necessary a regularity in attendance to training during the intervention period (Lopez et al., 2005). Meanwhile, the inclusion criterion for the inclusion in the sedentary group have been: to be woman aged 18 to 28 years old who have not done any training programme continuously in the previous three months, nor practiced any physical activity more than one day per week (Abián, 2008). Moreover, they can not be part of these groups and will cause exclusion of those women who had any surgical intervention in the lower limbs (Macrory et al., 1997) or structural deformities as: Genu valgum or varum, or coxa vara or valga (Escobar, 2007); or foot deformities as congenital valgus flat foot, flat foot paralytic or spastic equinus foot. Also, flat foot or cavus due to bone disorders or neuromuscular disorders (Viladot, 2000), to a serious injury or fracture in the past six months (Masaun, Dhakshinamoorthy and Parihar, 2009) or current pain in the feet (Scott, Menz and Newcombe, 2007).

Procedure

Footprints of both feet by photopodogram were recorded (Viladot, 2000) and analysed following the HC method (Hernández Corvo, 1989) and the IA (Cavanagh and Rodgers, 1987). We also measured the ATC (tibio-calcaneal angle) (Stacpoole-Shea et al., 1998; Viladot, 2000; Hertel, Gay and Deny, 2002, Lopez et al., 2005, Albert, 2009), the SH with the software "Autocad 2007" (Gómez, 2003; Billis et al., 2006; Nikolaidou and Boudolos, 2006) and manually the AE (Cowan, Jones and Robinson, 19 93; Chu et al., 1995, Williams, McClay and Hamill, 2001; Menz and Munteanu, 2005). Definitions and descriptions of each of these methods of footprint analysis is as follows:

- HC Method: This method involves typing stand as measures carried out according to the footprint. A good accuracy has been chosen, both in performance and in the classification of foot type, ranging from flat feet to end cavus (Sirgo and Aguado, 1991; Sirgo et al., 1997; Abián et al ., 2005, López et al., 2006; Zurita, Martínez and Zurita, 2007; Abián, 2008). The procedure is as follows (Figure 1): two points are marked in the innermost prominences of the footprint (1 and 1'), the "initial stroke" is made to connect the two points. After one point is marked on the anterior part of the footprint (including fingers) and other point in the rear part (2 and 2'). Perpendicular lines to the latter points from the initial stroke are drawn. The distance between this line and the point 1 is the "fundamental measure" and it must be transferred as many times as it fits in the initial stroke (3, 4 and 5). A perpendicular line to 3 is drawn, passing through the outermost part of the footprint, and another perpendicular to 4 and another to 5 as well as through the outer part (6, 7 and 8 respectively). The distance between the initial stroke and 6 is *X* (metatarsal width), the distance between 9 and 7 is *Y (*external arch, midfoot support surface).

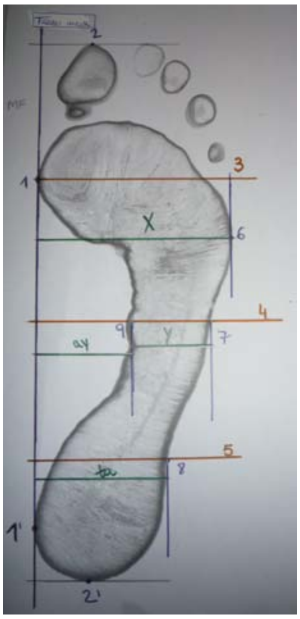


Figure 1. Assesment of the footprints according to the protocol of Hernández Corvo (1989).

With the obtained measures before and using the Equation 1 we will get the type of foot by the Hernández Corvo method (1989).

$$\%X = (X-Y) * 100/X$$

Equation 1. Equation of Hernández Corvo (1989) to assess the type of foot. 0-34%: Flat foot; 35-39%: Flat/normal foot; 40-54%: Normal foot; 55-59%: Cavus/normal foot; 60-74%: Cavus foot; 75-84%: High cavus foot; 85-100%: Extreme cavus foot.

- IA: It is defined as the ratio of the contact areas of the different parts of the footprint excluding the fingers. To divide the foot into three equal parts, the first axis of the foot must be taken, which is a line from the center of the heel to the top of the second toe. The IA is measured as the ratio of the area of the midfoot between the total area of the foot excluding the toes (Equation 2).

$$\frac{B}{A+B+C} = IA$$

Ecuation 2: Equation to assess the type of foot regarding the (If IA $\leq$ 0,21: cavus foot; normal foot: 0,21 < IA< 0.26; flat foot: IA $\geq$ 0.26).

- SH: The footprints were scanned with the software *Autocad 2007* (Figure 2) to measure their (Gómez, 2003; Yu, Lo and Chiou, 2003; Hurtado, 2006; Nikolaidou and Boudolos, 2006; Paiva et al., 2009).

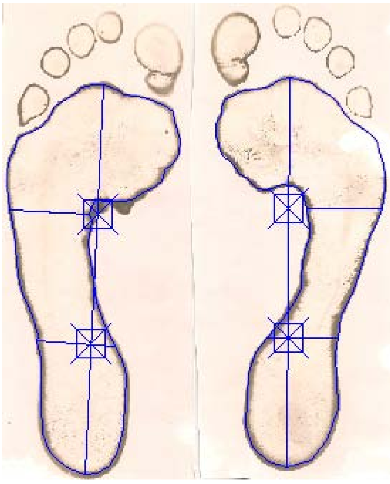


Figure 2. Assessment of the footprints surface with the software Autocad 2007.

- ATC: It is the angle formed the heel of the foot with the rest of the leg (Figure 3). According to Helbing line, the vertical has to go through the center of the popliteal fossa and the centre of the heel (Viladot, 2000; Hertel,Gay, and Denegar, 2002; Redmond, Crane and Menz, 2008; Albert, 2009). There is a degree of physiological valgus of about 5° to 10° according to Viladot (2000) and Albert (2009) and up to 7º according to Ricard (2001) in healthy men under 18. This line should be done with the foot relaxed, after putting the foot on the ground distributing the weight between both feet and then measured with a goniometer. Also measurements can be taken according to the horizontal with the ground (Sell et al. 1994; Elvira et al. 2008a; Elvira, Vera-García and Meana, 2008b), but in this study it has been done according to the first method of measurement. It was measured with a manual goniometer. According to Elvira et al. (2008a), the eversion and consequently the calcaneal valgus, is considered negative and the inversion or calcaneal varus considered positive when recording data. The following protocol was followed:

- Barefoot, in bipodal support stand on a smooth surface.
- It was marked with a pen the vertical line passing through the center of the popliteal fossa, up to the Achilles tendon.

- Other side is marked by the bisector of the calcaneus by reference to the posterior bulge, instead of the Achilles tendon insertion.
- Finally, the angle formed by two lines is measured with the goniometer.

Figure 3. Assessment of the angle formed by the heel and the leg.

- AE: The manually measurement of the navicular bone was used, taking as reference the navicular protuberance and measuring the distance from it to the floor. There are also more sophisticated methods to measure this variable, such as x-rays. Cowan, Jones and Robinson (1993) collect the navicular height measured manually and its correspondence with the type of foot that was observed in their study (measures taken in centimeters): Flat: 2.72-4.08; Normal: 4.09-5.08; Cavus: 5.09-6.05.

The procederes were as follows:

- Barefoot and with your weight distributed between both legs, draw a line through the tuberosity of the navicular by the lower part.
- Then, with one arm of the goniometer with a precision of 1 mm, placed in contact with the ground up to the line marked on the skin.

The method of obtaining the footprint has been the photopodogram (Figure 4) that, according to Viladot (2000), is the most useful for obtaining the footprint. Images were digitalised to make certain measurements, such as IA or the SH (Chu et al., 1995; Michelson, Durant and McFarland, 2002; Gómez, 2003; López e t al., 2006; Billis et al., 2006; Scott, Menz and Newcombe, 2007; Elvira, Vera-García and Meana, 2008b; Aydog et al., 2005a and 2005b; Menz and Munteanu, 2005 and Murley, Menz and Landorf, 2009). To obtain the photopodogram, the protocol described by Aguado, Izquierdo and González (1997) has been used. This protocol consists on brushing the sole with photodeveloper liquid photodeveloper and place the foot on photografic paper previously light veiled. Then, the support the foot on the paper is maintained for 45 s. After this time the foot is lifted. The paper with the footprint is put on a tray with fixer fluid. Finally, paper is taken off the liquid, washed very well with water and let it dry.

Figure 4. Photopodogram of left and right feet done by the potocol described by Aguado, Izquierdo and González (1997).

The measurements of FS and HH groups have been performed prior to the completion of exercise, i.e., before training (Cowan, Jones and Robinson, 1993). Similarly, the footprints were taken in bipodal position distributing the weight between both feet (Chu et al., 1995; Viladot, Cohí and Clavell, 1997, Shiang et al., 1998; Michelson, Durant and McFarland, 2002).

Variables

As dependent variables included in this study would be all measurements that were made at both times. So they would be the footprint analysis using the HC method, the IA, the delimitation of the SH, the ATC and the masurement of the AE measured manually. The intervention to the subjects would be the independient variable. This intervention has been the activity of the pre-season training in each of the sports (futsall and hockey). The duration of this intervention in both cases has been six weeks with a training load of three sessions per week and a duration of 2 hours per session. In the sedentary group the same time has been considered, but considering they had no change in their activity, i.e., they remained their sedentary condition.

Material

To describe the anthropometric characteristics of the population a *SECA* stadiometer *(SECA* Ltd, Germany) and a *SECA* floor scale *(SECA* Ltd, Germany) were used. For printing of the footprints by photopodogram, *ILFORD* photographic paper, developer and fixer liquid were used. Meanwhile, for the physiotherapic evaluation has been necessary to use a demographic pencil and a plastic standard manual goniometer, scaling by 2º in 2º, with a maximum error of 1, used by some specific studies to measure the angle of the rearfoot (Stacpoole-Shea et al., 1998, Kaufman et al., 1999; Hertel, Gay and Denegar, 2002). Also, an assessment template or proposed clinical examination assessing the sagittal alignment of the legs when standing (varus or valgus hindfoot and leg), the pelvic and possible slope d eformidad of the tibia (Salazar, 2007) was used. This template included also the grades of the tibio-calcaneus angle and the centimeters of the navicular height above the ground. For scanning and analysis of the images the software *"Autocad 2007" (Autodesk)* was used for the delimitation of the surface of the scanned footprints and obtaining the IA.

Statistical Analysis

Statistical analysis of the data was done using SPSS v.15.0 for Windows. Descriptive statistics have been conducted. Analysis was performed using repeated measures ANOVA, *post hoc* analysis used as the process of Scheffé. In the inferential tests the statistical criteria of significance of $p < 0.05$. have been used.

RESULTS

Here are the most important results that emerge from the study. Thus, the descriptive results of all the variables analysed in this study (ATC, HC, AE, SH and IA) for both right and left foot early in the preseason and the start of season are in Tables 2 and 3. Similarly, the differences found in each variable evaluated at different times.

Table 2: Differences in the right foot between the beginnng of the pre-season and the season.

	FS pre	FS seas	DIF	HH pre	HH seas	DIF	S pre	S seas	DIF
ATC (º)	-7.1 ± 3.9	-8.7 ± 5.4	-	-7.3 ± 2.8	-7.1 ± 1.2	-	- 6.7 ± 4.2	- 7.0 ± 4.1	-
HC (%)	66.07 ± 3.98	59.39 ± 9.29	*	62.94 ± 4.17	61.08 ± 4.77	***	66.44 ± 15.48	65.31 ± 14.56	-
AE (cm)	-	4.4 ± 0.6	-	4.0 ± 0.5	3.9 ± 0.4	-	3.9 ± 0.4	3.9 ± 0.4	-
SH (cm^2)	87.9 ± 15.2	90.1 ± 14.4	*	88.26 ± 8.14	90.0 ± 9.5	-	89.52 ± 12.33	93.5 ± 13.45	**
IA	0.23 ± 0.06	0.23 ± 0.04	-	0.23 ± 0.02	0.24 ± 0.03	-	0.22 ± 0.04	0.23 ± 0.04	-

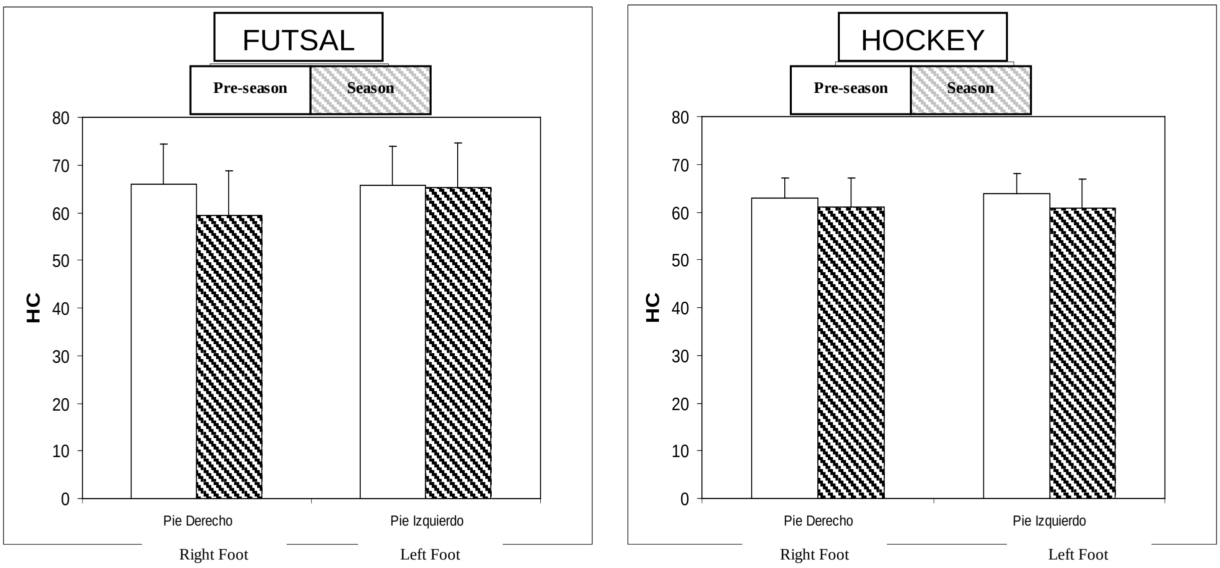
Results obtained in the right foot assesment at the beginning of the preaseason and the season ($\bar{x}$ = mean; σ = standard desviation; FS = futsal group; HH = hockey group; S = sedentary group; pre = measurement performed before preseason began; seas = measurement performed before season starteed (end preseason); ATC = tibiocalcanal angle; HC = type of foot following Hernández Corvo; AE = navicular height; SH = footprint surface; IA = arch index).

Table 3: Differences in the left foot between the beginnng of the pre-season and the season.

	FS pre	FS seas	DIF	HH pre	HH seas	DIF	S pre	S seas	DIF
ATC (º)	-6.8 ± 4.5	-8.1 ± 4.9	-	-8.3 ± 4.5	-7.6 ± 2.9	-	-6.6 ± 3.5	-7.2 ± 3.2	-
HC (%)	65.75 ± 8.22	65.23 ± 14.84	-	63.96 ± 7.20	60.88 ± 6.00	*	74.11 ± 19.66	74.95 ± 19.53	-
AE (cm)	-	4.3 ± 0.4	-	4.1 ± 0.4	4.0 ±0.3	-	4.0 ± 0.3	4.0 ± 0.4	-
SH (cm^2)	87.8 ± 11.1	88.7 ±12.8	-	87.5 ± 8.7	89.1 ± 8.3	*	84.5 ± 13.8	88.0 ± 15.2	**
IA	0.23 ± 0.03	0.22 ± 0.04	-	0.23 ± 0.03	0.23 ± 0.03	-	0.20 ± 0.05	0.21 ± 0.05	-

Results obtained in the left foot assesment at the beginning of the preaseason and the season ($\bar{x}$ = mean; σ = standard desviation; FS = futsal group; HH = hockey group; S = sedentary group; pre = measurement performed before preseason began; seas = measurement performed before season starteed (end preseason); ATC = tibiocalcanal angle; HC = type of foot following Hernández Corvo; AE = navicular height; SH = footprint surface; IA = arch index).

When performing statistical analysis of the variables it has been observed that there are no significant differences in any of the variables between the groups studied (FS, HH and S). Moreover, when comparing each group separately at different times of the preseason some significant differences in certain variables have been found. Thus, the FS group showed significant differences in the HC variable on the right foot only (not left foot) (Figure 5). Also, the HH group showed differences in this variable in both feet (Figure 6). Finally, the S group has not presented differences in either foot in this variable.



Figures 5 and 6. Differences in the footprint assessment in the Futsal and Hockey groups with the Hernández Corvo method in several points of the pre-season and season.

Furthermore, no significant differences were found in any of the groups in the IA variable. However, the SH variable has presented some differences, different in each of the groups. Thus, in the S group differences were observed in both feet, while in the FS group were observed only in the right foot and in the HH group were observed only in the left foot.

DISCUSSION

Differences between assessment techniques of the footprint

By comparing the results obtained with the methods used in this study to evaluate the footprint, IA and HC, we observe a high variability exists between them. Thus, using the HC method it could be considered that one foot is cavus, while evaluating the same foot by IA, we get a normal foot, in most cases. On the other hand, we must also consider that both methods use different classification ones. So the IA only considers three morphotypes of foot (flat, normal and cavus), while the HC method considers six (flat, normal, normal-cavus, cavus, high cavus and extreme cavus). In this regard, we believe that the HC method provides a broader classification, so a priori, it will make a more accurate differentiation between the different types of feet. Similarly, Wearing et al. (2004) concluded that the IA was closely related to the percentage of body mass and would be influenced by this parameter. The most significant limitation proposed by the authors of this study is that a measurement of medial arch height (taking only the footprint with a pressure platform, and digitised image t) is not incorporated. However, they still suggest that special care must be taken in measurements based on photopodogram footprint, such as the IA, in groups with higher percentages of lean mass. Nevertheless, Gómez (2003) suggests that there is a significant relationship between mass and footprint. According to him, under normal conditions a person weighing less than 60 kg can be normal footprint and be interpreted as a cavus according to this index.

Unlike these authors, Shiang et al. (1998) conclude that the parameters that take two or three dimensions, such as the IA, are better predictors of the arch than measures that are taken in one dimension, for example, the HC method. Similarly, authors like Abián (2008) also claim that the IA is a more effective method than the HC, as it may determine any error in any type of foot, as false cavus foot or not detect well the planes of first grade.

Regarding the AE, we must mention that one of the limitations, as claimed by Menz and Munteanu (2005), is that there are no values to classify certain types of foot and is difficult to make an assessment of their morphology. Therefore, it cannot be determined whether a foot is normal or abnormal. Thus, these authors showed a manually mean AE measured from the floor of 26.5 mm. In radiographs the average of AE is 31.1 mm. This value is lower than that obtained by Williams, McClay and Hamill (2001), whose size was 37 mm or by Cowan, Jones and Robinson (1993), whose measure was even higher, 46 mm. The fact that Menz and Munteanu (2005) obtained lower measures could be due to the number of subjects with less than 20 mm high navicular who participated in the study. Meanwhile, Nawoczenski, Saltzman and Cook (1998) obtained a mean of 40.2 mm in the height of the navicular tuberosity from the ground measured in RX. In our study AE values very similar to those obtained by Nawoczenski, Saltzman and Cook (1998),have been reported, which are around 40.6 mm.

Furthermore, Macrory et al. (1997) found a correlation of -0.71 between the IA and the standard AE and Williams, McClay and Hamill (2001) found a correlation between the AE manually measured with the X-rays of $r = 0.87$. However, these authors suggest that the measure of the navicular bone, by itself, does not provide a representation of the arch and to make it more valid, the standard AE (AE / foot length) should be used. Meanwhile, Murley, Menz and Landorf (2009) found a significant correlation between the clinical measures used (IA and normalized AE) and the measurements obtained with radiography, especially lateral ($p <0.05$). Chu et al. (1995) found correlations between the IA and the AE ($r = -0.70$) measured manually. Similar correlations were found by Shiang et al. (1998) and McCrory et al. (1997). However, these studies found no practical application to determine the foot type following the AE. Furthermore, Shiang et al. (1998) found correlation between the six methods of measuring the footprint with the AE. These methods were: Staheli Index, Chipaux-Smirak Index, Arc Angle, FPI, Truncated Arch Index and the Modified Arch Index. Unlike all these studies, our study found no correlation between the AI and the AE in either foot. Therefore, we agree with the study of Hawes et al. (1992), in which correlations were not found between the IA and the EA. These differences may be due to the implicit subjectivity of palpation of the navicular tuberosity or the soft tissue movement under the bone mark (McCrory et al., 1997).

SH Considerations

Depending on the results of this study, it would be possible to think that the variable SH, by itself, is ineffective in predicting the type of foot. There cannot be considered a measure of morphotype foot. This variable only provides the printed and digitised footprint. The SH is one more mesure that must be performed to obtain and classify the foot according to the IA method. In this respect, an equation determined in which the midfoot area is divided by the total area is used. Therefore, it can be considered only as a tool to determine the IA. It must be said that there have been differences in the SH measurements in different study groups. However, these differences have not caused a change in the type of foot through the IA method therefore cannot be considered as a good indicator to evaluate the type of foot.

In this sense, it is noteworthy that no author propose as the only measure of foot type assessment. Only Gómez (2003) uses this parameter to see the differences on the surface of the footprint before and after receiving a manipulation of the spine (specifically a posterior ilium).

Differences in terms of physical activity and sport

Sirgo and Aguado (1991) demonstrated acute adaptations that occurred in the foot as a result of a sporting situation (a volleyball game). These authors observed an increase in the footprint both longitudinally and transverse existing variations in terms of body composition (between ectomorphic and mesomorphic). According to these authors, it is expected that these acute changes become chronic over time in an individual athlete bowing the feet to a heavy load and effort. In our study, an increased percentage of the footprint by the method HC after a period of intervention has been found. Likewise, the type of sport practiced will have some influence (Sirgo et al. 1997). Thus, Sirgo et al. (1997) found differences in the footprint and support between players and swimmers.

Meanwhile, Lopez et al. (2005) found the same type of foot in football players from different levels. The results indicated that the majority of subjects had a normal foot and more valgus foot in the ATC in the right foot than the left one. These results are the same with those arising from the type of foot found in our study subjects using the IA method. In contrast, when using the HC method the morphotype foot results are closer to the cavus. In addition, López et al. (2005) found a cavus foot associated to calcaneal valgus, similarly to what has been found in our study. Volkov (1977), meanwhile, found a flattening of the plantar arch in young athletes practising ski and gymnastics. Unlike these, Elvira et al. (2008a) found that the racewalking did not cause asymmetry or specific adaptations to the foot type. However, significant differences between feet were found. These authors explain that this fact was caused by the circuit direction.

Furthermore, Aydog et al. (2005a and 2005b) found lower values of AI in dancers than in sedentary healthy subjects, in contrast to our study, where higher values were found in the groups of athletes than in the sedentary women group. Therefore, we consider that depending on the activity undertaken a different morphotype foot can be found..

Regarding gender, Igbigbi and Msamati (2002), found that men have higher AI values than women, and that through this method it had more probability of getting flat foot (24.26%) than using other methods. Comparing with the results of our study, it shows, as mentioned, that by HC method the three groups have a normal/cavus foot, with sometimes a tendency to cavus foot, while the IA method have a normal foot.

As stated by López et al. (2006), the usual tendency is toward an expansion of the footprint in all its parts (forefoot, midfoot and hindfoot), although regarding the training and sports activities, some areas will be more affected than others. In our study we observed the same in the two groups of athletes, the foot tends to flatten after the intervention period.

Kulthanan, Techakampuch and Bed (2004) found differences in the footprints of athletes and non-athletes. However, these authors used another type of measurements that have not been used in this study, such as the *Flat Indext* or the metatarsal distance. Thus, in our study differences between the footprints of the groups of athletes compared to the sedentary group were not found. However, differences in the sedentary group between the left foot and right foot were found.

These differences have not been found between the groups of athletes, coinciding with different authors (Sirgo and Aguado, 1991; Aydog et al., 2005a and 2005b; Cain et al., 2007) explaining that the sport causes certain changes in the foot type and that these variations occur evenly.

Differences between groups of athletes and the effects of the intervention

As seen from the results, no differences were found between the groups studied in this studies. This fact, could be due either to the number of subjects studied was not too high or because the intervention period was not sufficient to show the differences between the types of feet of different groups.

In our paper, we have taken measures of two feet at both times, before and after the intervention. There are some studies that have been conducted only measurements in the dominant foot (Hamilton et al., 1989; Cowan, Jones and Robinson, 1993; Elvira, Vera-García and Meana, 2008b). However, as we have seen, there are variations between feet, so that it becomes necessary to perform the evaluation of the two. Moreover, most authors use measurements of both feet (Sirgo and Aguado, 1991; Sirgo et al., 1997, López et al. 2005; Aydog et al., 2005a and 2005b; López et al., 2006, Elvira et al., 2008a).

Regarding the FS group, significant differences were found in the right foot after the intervention period, these differences were not found in the left foot. The differences showed a direction toward the flattening of the foot after the intervention period. These results may be due to the different functions that the feet perform in this sport. Authors such as Aydog et al. (2005b) obtained similar results in football players. These authors explained this fact by explaining the use of dominant foot in football. The foot that performs more functions (the dominant) will be modified by different morphology muscle and ligament strains and end up giving higher values in the different measurement methods. These authors also suggest that being a high-level athlete and be subjected to intense training, can also cause these structural changes in the musculoskeletal and ligamentous system. In the FS group of this study, all the players were right-footed, so they used it to dribble, control, pass and shoot. Therefore, the left foot is used only to support. Furthermore, according to Hamill et al. (1989), the differences between feet can be due to the increased muscle activity in the flat foot. Thus, the foot that has more activity or function, in this case the right foot, would show a tendency to flatten out. Therefore, it could also consider the technical gesture of stepping on the ball and stop the ball with the plantar forefoot, gestures widely used in football, can casue an upward displacement of the metatarsal head and consequently a stretching of the plantar fascia, which can give a flat foot tendency as observed.

On the contrary, in the HH Group both feet are used only for the locomotion function, having both the same rol, as the ball is hit with a stick and not with the lower limbs. In this case, because both feet are doing the same function in this HH group, significant differences have been found in both ones after the intervetion period.

Therefore, the differences found in the variable HC between th FS and HH groups may be due to the sport technique, since in the FS group, one foot is used as a pivot or support and the other to dribble, pass, control the ball and shoot, while in the HH group, both feet have the same role.

CONCLUSSIONS

- It cannot be stated that there is a dertermined foot morphotype associated to either the physical activity or the sport discipline practised in the groups analysed.
- The continued practice of physical activity and sport has caused different modifications in the studied players' footprints according to the discipline practised. These modifications have been provoked to the different techniques used in each sport.
- There is variability between the different methods that have been used to characterise the type of foot in the 3 groups participating in this study. Consequently, the Hernández Corvo method has been a method more

appropriate than the Arch Index to classify the type of foot studied. Furthermore, the footprint's surface has not been a proper method itself to classify the type of foot.

- The differences in the technique between football and hockey have provoked that the differences casued by the continued sport practised in the footprint in the participant analysed are different. Therefore, the futsal players have only had modifications in the dominant foot, while the hockey players have had them in both feet. In the sedentary group, there have not been found any differences.
- A higher heterogeneity in the foot morphotype in the analysed sedentary group has been found. The continued practice of physical activity and sport causes that the players participating in this study have showed a higher homogeneity in the their footprint.

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