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Pes planus and *pes cavus* in Southern Italy: a 5 years study

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Abstract

Introduction. Baropodometrical digital techniques map the pressures exerted on the foot plant during both static and dynamic loadings. The study of the distribution of such pressures makes it possible to evaluate the postural and locomotory biomechanics together with its pathological variations.

Methods. From January 2011 to August 2016 we conducted a cross sectional study in order to diagnose flatfoot and hollowfoot through the baropodometric analysis, and collecting additional information such as gender and the age. 7816 static and dynamic baropodometric tests and radiological exams of the spine in different positions were performed in order to detect, evaluate and verify the presence of spine pathologies or postural disorders. 978 patients were screened for suspected foot deformities: 668 cases of hollow feet and 310 of flat feet were diagnosed.

Results. Dividing patients in "younger" and "older" (> 60 years) according to WHO, there is a statistically significant difference in the prevalence of hollow feet and flat feet ($p < 0.01$): the young age is a risk factor for flat feet (OR = 1.61 CI 95% 1.22-2.11) but protective for hollow feet (OR = 0.62 CI 95% 0.47-0.81). There is a statistically significant difference ($p < 0.01$) due to sex in the prevalence of hollow feet (OR = 0.44 CI 95% 0.33-0.59) and flat feet (OR = 2.23 CI 95% 1.68-2.98): to be a man is a preventive factor for hollow feet, but a risk factor for flat feet.

Conclusions. Flatfoot and hollowfoot represent a serious public health problem which is related to working life because these deformities negatively influence the productivity of employees and the quality of life of affected patients.

Key words
- epidemiology
- prevalence study
- Italy
- *pes cavus*
- *pes planus*

INTRODUCTION

Pes cavus is a descriptive term representing a spectrum of foot deformities that may have varied aetiologies and clinical presentations. The cavus foot is defined as one in which there is an increase in height of the medial longitudinal arch of the foot that does not flatten on weight bearing. Perhaps more commonly discussed than the pure cavus deformity is the cavovarus foot, and these two terms are often used interchangeably as well as "claw foot" [1] and "hollow foot" [2]. A cavovarus foot is typified by first ray plantarflexion, forefoot pronation and hindfoot varus [3]. Clawing of the toes is also frequently associated with a *pes cavus* deformity.

Pes planus ("flatfeet") is described as the loss of the medial longitudinal arch of the foot, valgus deformity of the heel and medial talar prominence. The deformity is usually asymptomatic and resolves spontaneously in the first decade of life, or occasionally progresses into a painful rigid form which causes significant disability. Several factors have been identified to contribute to the etiology of flatfoot. These factors include ligamentous laxity, equinus deformity of the foot, tibial torsional deformity, presence of the accessory navicular bone, congenital vertical talus and tarsal coalition. Although it is not obvious, obesity is also accepted as one of the possible factors related to flatfoot [4, 5]. Previous studies [6-8] indicate the prevalence of flatfoot between < 1% and 28% at certain age groups.

Baropodometrical digital techniques map the pressures exerted on the foot plant during both static and dynamic loadings [9, 10]. It allows to record plantar imprints and ground reaction forces in the support area during quiet standing (upright position), divided by feet (right and left) and subdivided in three regions named "forefoot", "midfoot" and "backfoot" for each foot. For each foot it can also be calculated an arch index defined by percentage of total foot load on the midfoot imprint, informing kinds of feet [11, 12]. The study of the distribution of such pressures makes it possible to evaluate the postural and locomotory biomechanics together with its pathological variations [9, 10].

In our study, we used computerized baropodometric

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analysis to make diagnosis of *pes planus* and *pes cavus* in the population of Foggia (Apulia Region, Southern Italy). The aim of our study was to calculate the prevalence and to show significant differences due to gender or age.

METHODS

We conducted a cross sectional study from January 2011 to August 2016, in the Orthopaedic Ambulatory of the Local Health Unit of Foggia, Italy. The patients were asked to sign a consent form to participate in the study. The baropodometric analysis was performed by an orthopaedist to diagnose flatfoot and hollowfoot, and additional information such as gender and the age were recorded. We calculated percentages, means and standard deviation. The Chi-square test, and the calculation of Odds Ratio were used to identify differences due to these variables (sex and age). The collected data were organized and processed by software Stata® SE, version 12.1 (StataCorp, College Station, Texas, USA). The level of significance was set at $p < 0.05$.

RESULTS

From 2011 to 2016, we performed 7816 static and dynamic baropodometric tests and radiological exams of the spine in different positions in order to detect, evaluate and verify the presence of spine pathologies or postural disorders. 978 patients were screened for suspected foot deformities: 668 cases of hollow feet and 310 of flat feet were diagnosed.

Table 1 shows the composition of our sample; *Table 2* and *Table 3* show the cases of *pes cavus* and *pes planus* per age and gender.

Patients with hollow feet had an average age of 50.4 years (SD 22.6); patients with flat feet an average age of 39.88 years (SD 30.4). The most numerous cases are in the group 4-10 years old for flat feet (35.48%); 50-60 (22.16%) and 60-70 years old (19.31%) for hollow feet.

Dividing patients in "younger" and "older" (> 60 years) according to WHO [13], there is a statistically significant difference in the prevalence of hollow feet and flat feet ($p < 0.01$): the young age is a risk factor for flat feet (OR = 1.61 CI 95% 1.22-2.11) but protective for hollow feet (OR = 0.62 CI 95% 0.47-0.81).

Table 1
Composition of the 978 patients screened for suspected foot deformities

	N	Males	%	Females	%
4-10 years old	158	89	9.10	69	7.06
10-20 years old	123	50	5.11	73	7.46
20-30 years old	40	15	1.53	25	2.56
30-40 years old	52	23	2.35	29	2.97
40-50 years old	90	15	1.53	75	7.67
50-60 years old	166	20	2.04	146	14.93
60-70 years old	183	39	3.99	144	14.72
70-80 years old	125	24	2.45	101	10.33
> 80 years old	40	25	2.56	15	1.53
Total	978	300	30.67	677	69.22

In the group of flat feet men represented the 41.61% (n = 129) of the sample; women the 58.39% (n = 181); in the group of hollow feet men were the 24.10% (n = 161); women the 75.75% (n = 506).

There is a statistically significant difference ($p < 0.01$) due to sex in the prevalence of hollow feet (OR = 0.44 CI 95% 0.33-0.59) and flat feet (OR = 2.23 CI 95% 1.68-2.98): to be a man is a preventive factor for hollow feet, but a risk factor for flat feet.

DISCUSSION AND CONCLUSIONS

In our study we identified 310 cases of *pes planus*: the young age and male gender represented a risk factor (OR = 1.61 CI 95% 1.22- 2.11; OR = 2.23 CI 95% 1.68-2.98 respectively) for the disease.

Our results are partially in line with literature: in some studies the prevalence varied to as high as 67% in males and 49% in females [14] to as low as 14.2% and 15% [15]. Three studies investigated associations with age, all finding that prevalence of *pes planus* decreases with increasing age [6, 14, 16]. However there are some studies with opposite results: Pita Fernandez et al. in their study, showed that female gender, and age were associated with the prevalence of flatfoot [17]. The study conducted by Dunn described how podological pathologies increased with age [18], while others describe how flatfoot decreases with age after adjusting for other covariables [19] or indicate that neither age, gender, nor BMI are related to flatfoot.

As for hollow feet we identified 668 cases: the young age (OR = 0.62 CI 95% 0.47-0.81), and male gender (OR = 0.44 CI 95% 0.33-0.59) represented protective factors. As showed by Derya Atamturk [20] *pes cavus*, has a tendency to emerge in later years, especially in age group of 50-59 years, but its prevalence is higher in males (2.0% *vs* 0.4% in females).

In fact, *pes planus* if often an acquired disease, caused by neurological disease, and hereditary sensorimotor neuropathies [21]. Although the most common condition causing *pes cavus* is a sensorimotor neuropathy, especially Charcot-Marie-Tooth disease, other very important conditions must be considered, such as tumors or birth defects of the spinal cord (diastematomyelia, syringomyelia, etc.) [22]. So when it appears to be acquired *pes cavus*, an examination by a neurologist is usually required [21].

Flatfoot and hollowfoot, at the same time, are a serious public health problem which is related to working life because these deformities negatively influence the productivity of employees [23]. Some studies investigated the Quality of life of patients with foot deformities. A 6-year follow-up of the North Staffordshire Osteoarthritis Project found a progressive reduction in all SF-36 component scores as the severity of hallux valgus increased, a condition usually associated with flat foot [24]. Kothari *et al.* [25] and Lopez *et al.* [26] evaluated the impact of foot arch height on quality of life of children showing that arch height has a negative impact on their quality of life. It would be interesting to continue our study evaluating through the SF-36 questionnaire [27-29] the quality of life for patients affected by *pes planus* and by *pes cavus*, in order to

Table 2
Cases of hollow feet per age and gender

	N	%	Females	%	Males	%
4-10 years old	48	7.19	35	5.24	13	1.95
10-20 years old	94	14.07	56	8.38	38	5.69
20-30 years old	32	4.79	22	3.29	10	1.50
30-40 years old	40	5.99	26	3.89	14	2.10
40-50 years old	77	11.53	65	9.73	12	1.80
50-60 years old	148	22.16	130	19.46	18	2.69
60-70 years old	129	19.31	99	14.82	30	4.49
70-80 years old	73	10.93	58	8.68	15	2.25
> 80 years old	26	3.89	15	2.25	11	1.65
Total	668	100.00	506	75.75	161	24.10

Table 3
Cases of flat feet per age and gender

	N	%	Females	%	Males	%
4-10 years old	110	35.48	34	10.97	76	24.52
10-20 years old	29	9.35	17	5.48	12	3.87
20-30 years old	8	2.58	3	0.97	5	1.61
30-40 years old	12	3.87	3	0.97	9	2.90
40-50 years old	13	4.19	10	3.23	3	0.97
50-60 years old	18	5.81	16	5.16	2	0.65
60-70 years old	54	17.42	45	14.52	9	2.90
70-80 years old	52	16.77	43	13.87	9	2.90
> 80 years old	14	4.52	10	3.23	4	1.29
Total	310	100.00	181	58.39	129	41.61

complete the previously published studies and to establish the real impact of these diseases on the lives of affected patients.

Conflict of interest statement

There are no potential conflicts of interest or any financial or personal relationships with other people or organizations that could inappropriately bias conduct and findings of this study.

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