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Research Article

Foot Arch Differences in Elderly People at Standing: Considering Gender and Age

Michel Bertani[1,2], Denise Soares[1,2]*, Everton Rocha[1,2] and Leandro Machado[1,2]

[1]University of Porto, Faculty of Sports, Rua Dr Placido Costa, 91-4200-450 Porto, Portugal
[2]LABIOMEP - Porto Biomechanics Laboratory, Rua Dr. Plácido Costa, 91, 4200 450 Porto, Portugal

***Address for Correspondence:** Denise Paschoal Soares, University of Porto, Faculty of Sports, LABIOMEP-Porto Biomechanics Laboratory, Rua Dr. Plácido Costa, 91, 4200 450 Porto, Portugal, Email: dsoares@fade.up.pt

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ABSTRACT

Background: The foot is an important and complex structure that provides support, balance and propulsion to locomotion, thus, its proper care can help to have a better life quality avoiding pain. The medial longitudinal arch is an important structure that is related to injury risks when it shows some impairment. The purpose of this study was to characterize the foot arch index in people in relation to age and gender.

Methods: The sample was composed of a total of 122 subjects, 79 healthy young subjects (40 women and 39 men) and 43 healthy elderly subjects (32 women and 11 men). Ten seconds of standing barefoot plantar pressure was measure through Tekscan F-Scan device, and the data processing, filtering, and arch index (AI) calculation were performed using MATLAB™ 7.0.

Findings: The elderly group presented a lower arch (AI-0.23) than the young group (AI-0.13) (p=0.000); young female and male groups show similar AI, while the elderly female group showed lower arch (AI-0.23) than the elderly male group (AI-0.18) (p=0.033).

Interpretation: The foot arch has a trend to be lower with aging, and even lower within elderly female subjects, probably due to some decrease within plantar muscle's stiffness, that in turn may be related to lower physical activity and footwear choices.

INTRODUCTION

The human feet are very complex, having different components working together to create a complex flexible structure providing support, balance, and mobility to the body. There are two main functions for the foot during walking: a passive function which protects the human body from impact forces and an active function to transfer internal forces to the ground [1]. The foot arch is important in lifting the body weight and shock absorption, which makes the arch a very important factor on walk and run safety, thus making direct influence on the biomechanics of an individual in case of any change [2].

Foot arch types can be classified by the Medial Longitudinal Arch (MLA) as high arch (cavus foot), normal arch (retus foot) or low arch (planus or flat foot). Both flat foot and high arch foot do not transmit forces efficiently and might lead to foot diseases [3]. High arched feet allow less motion and are identified as a risk factor for lateral ankle injury, stress fractures, and anterior knee pain while low arched feet have been shown to be at increased risk for medial tibial stress syndrome, knee pain, and other injuries involving the medial and soft tissue structures of the lower extremity [4].

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Several techniques for classification of foot type are described in the literature, which measure the morphology and foot posture in a static position or during locomotion. Within the morphological classification techniques of the foot when standing are: visual inspection non-quantitative, anthropometric values, footprint parameters, radiographic evaluation [5-7]. Among these types of techniques there are pro and cons to all of them, as well as subjectivity and dependence of the experience of the evaluator (visual assessment techniques or by palpation) or expensive costs such as for the radiographic techniques [8]. The plantar arch index [5] has been shown in some studies to be a reliable way to calculate the foot type of the subject [9], and by using plantar pressure measurement devices, believed to be an affordable, fast and reliable way to measure and classify the foot type [7].

According to Zifchock (2006), understanding the differences in arch structure may bring an insight into the prediction for injuries between genders, age, and between sides of a given subject [10]. The knowledge about foot problems related with the foot arch is important in helping to design proper footwear that prevents or helps to release pain and disorders on the feet and lower limbs [11]. Such concern is particularly valid for the elderly population, which have showed specific characteristics that differs according to age, sex and individual behaviors [8].

Elderly people have shown to have flatter, longer and wider feet than younger adults, and also older adults with osteoarthritis show greater dynamic loading of the midfoot when walking, due to the lower arch [6]. In a gender differences study, [12] showed that women have less arch stiffness than males and their arch is more flexible under both static and dynamic weight-bearing conditions.

Due to the importance of the knowledge about the appearance of certain foot arch types among the elderly population, which would help to develop techniques to prevent pain and even help to design proper elderly footwear, the aim of this study was to characterize the foot arch index in elderly people in relation to age and gender.

METHODOLOGY

Sample

The young group was composed of a total of 79 healthy subjects (40 women and 39 men. They went voluntarily to the Biomechanics Laboratory for the collection of data, where they freely signed an informed consent accordingly to the Helsinky protocol.

The elderly group was formed after a contact with the manager of the Elderly Day Care from the Social Center enrolled, who allowed inviting the elders subscribed on the social center program to voluntarily participate in this study. A total of 43 healthy elderly subjects (32 women and 11 men), without previous comorbidities related to autonomous capability of gait enrolled the study. Those subjects who showed any kind of limitation or pain during walking were excluded. All volunteers freely signed an informed consent accordingly to the Helsinky protocol. The project was approved by the ethical committee of the institution involved in the Study. The caractherization of sample is showed in table 1.

Protocol

The procedure of data collection followed the sequence: anthropometric measurements (height and weight), questionnaire related to comorbidities, equipage of slipper with Tekscan insole, calibration of weight into the Tekscan® software, adaptation to the standing position, and when subject is judged stable, 10-s recording of footprint and plantar pressure were performed. In the process of adapting to the position, subjects were asked to stand in both feet in the anatomic position with eyes open looking forward to the horizon.

Both feet of all participants were analyzed. The contact area of the foot, excluding toes, was divided into three equal parts: the forefoot, midfoot and hindfoot. After

calculating the active area of each part, the arch index was calculated dividing the area of the midfoot by the sum of the three areas (midfoot / [forefoot + midfoot + hindfoot]). Arch indices ≥0.260 were considered low-arched; arch indices between 0.210 and 0.260 were considered normal; and arch indices ≤0.210 were considered high-arched [5].

Instruments and Devices

The device used to measure foot pressure distribution was F-SCAN (TEKSCAN inc., Boston, MA, USA). The insole model used was the 3000/P1/0600T1/REG. The sensor matrix was distributed over 60 rows and 21 columns, with a sensor interval of 5.1 mm. Sampling frequency was set to 100 Hz. To reduce the effect of random noise, the data was filtered using a 4th order butter-worth filter with cutoff frequency of 4Hz.

Data Processing and Statistics

The data processing, filtering, and arch index calculation were performed using MATLAB™ 12.0 (MathWorks, Massachusetts, USA).

The statistics procedures were performed using SPSS 23 program. Normality and homogeinity of variances was formaly tested using Shapiro-Wilk and Levene's tests respectively. Once the formal test of normality of the distribution and the formal test for homogeinity rejected the null hypotesis, were performed the non-parametric test of Krustal-Wallis.

RESULTS

A total of 122 subjects (244 feet), which were separated into groups to be compared were analyzed: by age - young people (between 18 and 65 years) and elderly (over 65 years); by gender - men and women (in subgroups older men, older women, young men and young women) [Table 2].

The results showed differences statistically significant in all comparisons of means, except at the comparison of means in the young sub-group on gender.

Considering age, the elderly group had a mean arch index of 0.23 (±0.10), an average that classifies the group as normal arch, while the youth group had a mean index of 0.13 (±0.10), which classifies the group as high arch (cavus foot), showing a statistical significance (p=0.000).

Comparing genders, young females and males had a very similar average of

Table 1: Characterization of sample.

	Age (years)	Weight (Kg)	Height (m)	IMC (kg/m²)
Young women	24.24±5.73	60.59±12.11	1.61±0.06	23.37±3.34
Young men	26.00±5.71	78.03±16.75	1.75±0.06	25.48±2.80
Elderly women	73.28±7.73	72.68±11.87	1.52±0.06	31.46±2.49
Elderly Man	73.91±7.01	76.35±10.95	1.65±0.07	28.04±1.37

Table 2: Arch Index's means and standard deviations for the groups of interest and comparisons between groups with Krustal-Walils test.

	Mean	Std. Dev.	N	p-value
Young	0.13	0.10	79	0.000
Elderly	0.23	0.10	43	
Young Female	0.14	0.11	40	0.774
Young Male	0.13	0.10	39	
Elderly Female	0.23	0.09	32	0.033
Elderly Male	0.18	0.10	11	

arch index (0.14 and 0.13, respectively), without statistical significance (p=0.774); however elderly male=0.18 (±0.10) and elderly female 0.23 (±0.09), showed a statistic significant difference (p=0.033).

DISCUSSION

The aim of this study was to characterize the foot arch in elderly people comparing with a younger group and considering gender. Whereas foot type is related to foot function [2,13], it is important to perceive the difference of foot arch between ages and genders, to help prevent risk of injuries [14].

The results of this study indicate that during standing the elderly group has flatter feet comparing to the young group, showing higher arch index mean. It corroborates with a previous study of [15] which found that feet changes with ageing in multiple aspects including arch height, although the author says that only women tend to develop lower arches, men tend to maintain a normal or high arch.

Paiva et al. (2011) found that the women's feet were proportionally wider than the men's, whose feet had proportionally larger values for height of the dorsal foot but the Arch Index did not reveal significant differences between genders. 12. Fukano found that the foot was more flexible in the females than in the males, although they suggest that there is no sexual dimorphism in the longitudinal arch morphology of the foot under no-load conditions [12].

The other hand, in this study, older women, although plantar arch index within the normal range showed values closer to flat feet than elderly men (0.23 against 0.18 of men's arch index), In this study it is revealed that somehow the foot tend to turn flatter with aging and even flatter if it was a woman becoming older. But it is important to note that our elderly sample belongs to a single institution and that due to the small sample size of this group should avoid generalizations to the population. Also, it is well known that IMC can influence the arch index, but since both elderly groups (male and female) presented an average IMC above 25 classified as overweight, this influence does not explain the differences between these groups.

There are some factors that this study did not encompass like plantar muscle's stiffness or behavior of physical activity, which are relevant factors on the foot arch transformation through aging. Further investigations over physical activity level on elderly people and foot type can provide better understanding about the aging process of the foot, also a comparison between static and dynamic measuraments could provide a wider vision over the importance and the influence of the foot arch on the lower limb welfare.

CONCLUSIONS

This study showed that the foot arch change with aging, turning into a flatter foot. The differences between men and women on their physical activity behaviors or footwears through their aging, turn the women's foot arch lower than the men's. These findings showed the importance of taking care about the particularly of each elderly's footwear. As we know, unless they are custom maded, the elderly's shoes do not come out of the factory differing from male to female aspects.

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