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Determination of plantar pressure in people who use orthoses of the foot

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Abstract

Objective: *to know the transfer of static plantar pressures and body weight distribution through the lower limbs that occur in people with and without the use of orthoses of different densities and influence in other areas of the foot.* **Material and Methods:** *32 people participated through non-probability convenience sampling in a quasi-experimental study in which self-reported data were recorded, the determination of plantar pressure, and body weight distribution.* **Results:** *64 feet were studied, showing no difference between the medium pressure and the forefoot without orthoses of 5 mm and 10 mm. Decrease in average pressure and percentage of body weight, both statistically significant, with hindfoot orthoses 10 mm was observed.* **Conclusions:** *Given the current evidence for the prescribing and use of foot orthoses is limited, designed to improve the functionality and prevent the onset of disease and foot deformities, these results highlight the need to prescribe orthotics 10 mm when needed to relieve pressure on the backfoot, not seeing the average pressure increased nor diminished in other areas of the foot.* (Gac Med Mex. 2015;151:297-300)
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Introduction

Customized foot orthoses have been designed to reduce the frequency of lesions and to enable postural stability or neutrality, defined as the foot position where the angle formed by the lower leg distal third bisection line and the calcaneal bisection is 0º[1,2]. The lack of foot alignment is a significant predictor of pain ocurrence, increased risk of falls and decreased physical activity, which are attributted to postural unstability, resulting in worsened quality of life[3-5]; it is also associated with a reduction in physical activity and it has been shown to increase all-cause mortality[6,7].

The efficacy of medical and orthopedical intervention has been limited to an immediate response to initial application of customized foot orthoses, and orthoses have been suggested to act as a filter of forces acting on the foot sole and that then are transmitted to the nervous central system to start adequate dynamics[8], although it is dificcult to clearly establish the mechanism by means of which orthoses work, especially because most studies have been conducted with healthy people[9,10]. Based on these backgrounds, and taking

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into account the necessity of knowing predictors of plantar pressures distribution, the need to put into practice practical clinical interventions to improve the influence generated by the distribution of pressures is established. Customized orthoses have been identified as a mechanism that decreases the force exerted by the feet when walking, and are a factor to be taken into account when treatments and preventive activities are planned in order to improve quality of life and wellbeing of people. Therefore, the aim of the study is to determine plantar pressure in persons in different situations (with and without 5 and 10-mm high-density polyethylene foam customized orthoses) and to assess the influence of plantar pressures on the rest of the foot areas in the adult population.

Material and methods

Patients

A total of 32 subjects participated in this quasi-experimental study; they were observed in a single outpatient center, where they were recruited over a 6-month period. The selection of study subjects was made using a non-probabilistic convenience sampling. Subjects younger than 65 years of age were included in the study and those participants with some of the following characteristics were excluded: immunodepression, previous trauma and history of feet surgery, neurological disturbances, lack of autonomy/semi-autonomy in daily activities, refusal to sign the informed consent and inability at the moment of understanding the study instructions and carrying it out. The research was approved by the Universidade da Coruña (Spain) Board of Research and Ethics with file number CE 03/2014. All volunteers gave written informed consent prior to inclusion in the trial, and the ethical standards for research on human beings of the Declaratioin of Helsinki (World Medical Assembly), the Council of Europe Agreement with regard to human rights and biomedicine, the UNESCO Universal Declaration on human genome and human rights, as well as those of relevant national or institutional organizations, were preserved.

Procedure

Measurements were carried out by a single clinician, who first measured height and weight, and then calculated the body mass index (BMI).

Once the participants removed their shoes and socks, a single investigator assessed and recorded the length of foot and shoe using a Brannock-type measuring device, which is a validated instrument for this purpose[11]. Each participant stood up, barefoot and relaxed, feet slightly apart and weight evenly distributed between both feet; aided by the investigator, the subject introduced the foot in the device, from the most posterior zone of the calcaneus to the tip of the longest toe (it is important taking into account that the longest toe did necessarily not have to be the first). The same protocol was established for the other foot and to determine the measurement of the shoes.

Subsequently, static plantar pressures and body weight distribution on the lower limbs were determined using the portable platform system EPS Footchecker 4.0, which allows the recolection of plantar pressure and body weight distribution on the lower limbs in a reliable manner, since it is a diagnostic tool that enables their study[12]. Alterations in the biomechanical analysis are a characteristic sign of several pathological conditions and abnormalities, which allow for rapid and accurate diagnosis of patients and aid in the guidance of treatment in clinical practice.

This way, the measurements of plantar pressure and body weight distribution on the lower limbs of subjects without customized orthoses were recorded. The volunteer stood up on the pressure platform and simulated walking in place for 15 s; then, the subject stood naturally on the platform and in a comfortable position, looking towards the front, arms close tight to the body, and both feet plantar-pressure and body weight distribution on the lower limbs were simultaneously recorded over a 30-s period[13,14]. If the individual moved during this period, the data collection was discarded and the test was repeated until successfully performed. The same sequence was established for the collection of plantar pressure and body weight distribution on the lower limbs of study participants with high-density polyethylene foam customized orthoses. With regard to composition and density of the materials, customized orthoses consisted of two pieces: a long one, or base layer, of 1 mm, which accommodated the entire foot perimeter, and a short one, or heel pad, which covered the hindfoot zone, with a density of 4 and 9 mm; total thickness of the orthosis was 5 or 10 mm.

The IBM SPSS Statistics 19 for Windows statistical package was used for data analysis and a descriptive analysis was performed of the variables included in the study. Qualitative variables were presented as absolute values and percentages; of the quantitative variables, the mean and standard deviation (SD) were described. Means comparison was made using Student's

Table 1. Demographic and clinical data

Characteristics	Mean	SD	Range
Age (years)	24.2	2.99	21-33
Weight (kg)	66.94	13.60	48.6-113
Height (cm)	166	9.8	151-186
BMI (kg/m^2)	24.01	3.7	19.43-34.88
Foot size	39.8	2.79	35-45

t-test for paired data, after comparing for normality with the Kolmogorov-Smirnov test. The record of plantar pressures and body weight distribution on the lower limbs was obtained using the Footchecker 4.0 program.

Results

Sample characteristics

A total of 32 adult individuals completed the course of the research. Of the analyzed sample, 12 (37.5%) subjects were male and 20 (62.5%) were female. The remaining characteristics of the sample are shown in table 1.

Overall study population was young and had a normal BMI. The plantar pressure analysis showed that, with regard to baropodometric parameters, there were no significant differences in forefoot mean pressures without and with the use of different density 5 and 10-mm polyethylene foam customized orthoses. With regard to the influence on the rest of the foot areas, statistically significant differences were confirmed in the hindfoot mean pressure between the subjects who did not use customized orthoses and those who used 10 mm customized orthoses (details in table 2).

If differences between mean pressure percentages measured in the forefoot and the hindfoot are compared with the proportion of theoretical mean pressure, statistically significant differences are also observed in body weight distribution on the lower limbs that is produced in people without and with the use of customized orthoses of different densities and their influence on the rest of the foot areas (Table 3).

Table 2. Differences between forefoot and hindfoot mean pressures without and with 5 and 10-mm customized orthoses

	Mean	Difference	95% CI		p
			Lower	Upper	
Forefoot					
Without customized orthosis	13.3				
5-mm customized orthosis	12.5	0.8	–1.3	2.9	0.435
10-mm customized orthosis	11.2	2.1	–0.3	4.2	0.092
Hindfoot					
Without customized orthosis	12				
5-mm customized orthosis	12	0	–1.3	1.2	0.906
10-mm customized orthosis	9.7	2.3	0.7	3.7	0.005

CI: confidence interval

Table 3. Difference between forefoot and hindfoot-measured mean pressure percentage and theoretical mean pressure proportion

	Mean pressure (%)	Difference	95% CI		p
			Lower	Upper	
Pressure on forefoot					
Theoretical	40	–11	5.9	16.2	0.000
Measured	51				
Pressure on hindfoot					
Theoretical	60	11	7.5	14.6	0.000
Measured	49				

CI: confidence interval

Discussion

The main findings of this study were the statistically significant differences in static peak pressure and the percentaje of body weight born at the hindfoot zone level without the use of customized orthosis compared with the use of 10 mm high-density polyethylene foam customized orthoses. The use of asymptomatic feet is useful as it allows for many confounding variables, such as age, weight and physical activity differences, to be avoided[13]. Our results indicate that, in an asymptomatic person, the percentage of support and pressure decreases in the heel zone, without increasing the pressure in other areas of the foot with the use of 10 mm-density customized orthoses. These results might be useful at the moment of ortopedic devices prescription by clinicians, when considering the manufacture of 10 mm high-density polyethylene foam customized orthoses as a treatment that improves the pathological condition and functionality of the hindfoot zone, since the feet are a key element for movement, adptation to the ground and for people's autonomy[15]. In addition, the high percentage of medical conditions and injuries occurring in this zone, correlated with the presence of feet alterations and deformities[16], and neuromuscular diseases, as well as the association with abnormal distribution of body weight between both extremities and pressure excess on the heel, highlight the need for therapeutic approaches to be optimized in order to improve the quality of life and wellbeing of people.

Finally, at the time of foot's health assessment, especially in the primary health care level, in addition to the preventive physical exam by the physician, where intrinsic and extrinsic risk factors are evaluated[17], determination of plantar pressures and body weight distribution would be desirable as complementary testing in the diagnosis of feet alterations and deformities, in order to reduce the prevalence o these problems, since these are key aspects that contribute to improve the health, quality of life and autonomy of people.

Conclusions

Taking into account that current evidence for the prescription and use of customized orthoses is limited and intended to improve functionality and prevent the onset of feet conditions and deformities, among other issues, these results highlight the need to prescribe 10 mm high-density polyethylene foam-manufactured orthopedic devices when hindfoot pressure is required to be reduced without mean pressure on the rest of the areas of the foot being increased or reduced. Further research is needed relating customized orthoses, in order to identify other causes involved with plantar pressures, and to understand factors contributing to abnormal distribution of body weight on the lower limbs.

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