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ORIGINAL ARTICLE

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Static electronic baropodometry in patients with metatarsalgia

Baropodometria eletrônica estática em pacientes com metatarsalgia

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ABSTRACT

Objective: To analyze the values obtained by electronic baropodometry in patients with metatarsalgia.

Methods: A retrospective observational study of medical data (gender, height, weight, body mass index, foot laterality, shoe size and clinical diagnosis) and values obtained by static electronic baropodometry (load distribution and maximum and mean pressure) was performed. A total of 39 patients with clinical complaints of metatarsalgia were selected and subjected to static electronic baropodometry.

Results: Female gender was more prevalent (58.9%) among patients, and 61.53% of the patients were overweight or obese. The mean maximum pressure was 1.76kgf/cm^2, and the forefoot-to-rearfoot load distribution ratio was 0.86. There was a significant correlation between body mass index and maximum pressure. No correlation was found with shoe size.

Conclusion: The baropodometry values measured in this study were similar to those reported in the literature. Obese and overweight patients had a higher maximum pressure value, which suggests a higher risk of metatarsal pain in this population.

Level of Evidence III; Diagnostic Studies; Study of non consecutive patients; Without consistently applied reference "gold" standard.

Keywords: Metatarsalgia; Gait; Pressure; Foot diseases/diagnosis.

RESUMO

Objetivo: Analisar os valores obtidos em baropodometria eletrônica em pacientes com metatarsalgia.

Métodos: Estudo retrospectivo observacional de dados de prontuário (gênero, altura, peso, IMC, lateralidade do pé, tamanho do calçado e diagnóstico clínico) e de valores obtidos em exame de baropodometria eletrônica estática (distribuição de carga, pressão máxima e média). Foram selecionados 39 pacientes com queixa clínica de metatarsalgia e que foram submetidos à baropodometria eletrônica estática.

Resultados: O sexo feminino foi mais prevalente (58,9%) e 61,53% dos pacientes apresentavam sobrepeso ou obesidade. A média do valor de pressão máxima foi de 1,76kgf/cm^2 e a relação de distribuição de carga no antepé/retropé foi de 0,86. Houve correlação significativa entre IMC e valor de pressão máxima. Não foi encontrada correlação com o tamanho do calçado.

Conclusão: Os valores de baropodometria obtidos neste estudo foram semelhantes ao obtido na literatura. Obtivemos um maior valor de pressão máxima em pacientes obesos e com sobrepeso, podendo sugerir um maior risco de dor metatarsal nesta população.

Nível de Evidência III; Estudos Diagnósticos; Estudo de pacientes não consecutivo; Sem padrão de referência "ouro" aplicado uniformemente.

Descritores: Metatarsalgia; Marcha; Pressão; Doenças do Pé/diagnóstico.

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INTRODUCTION

Metatarsalgia is the most frequent cause of foot pain and may be present in isolation or associated with other pathologies[1,2]. It can be defined as pain in the forefoot under the head of one or more metatarsals[3]. Factors such as foot anatomy, excessive force application during walking, exercise types, footwear and systemic diseases can trigger this type of pain[3,4].

The causes of metatarsalgia can be divided into three major groups: primary, secondary and iatrogenic. The primary causes are related to anatomical alterations of the foot and metatarsals, including alterations of the hallux valgus, congenital deformities of the metatarsal heads, gastrocnemius stiffness and excessively high arch. Secondary metatarsalgia is caused by conditions that indirectly lead to increased load, such as chronic synovitis, rheumatoid arthritis, gout, fracture sequelae and Freiberg's disease. Lastly, iatrogenic metatarsalgia can be caused by forefoot surgery[3].

The diagnosis of metatarsalgia is established based on clinical examination and imaging tests such as radiographs and magnetic resonance imaging[5]. The analysis of plantar pressure distribution through an electronic recording platform – electronic baropodometry – has been an increasingly studied and used resource in metatarsalgia evaluation[6].

In addition to its value as a complementary diagnostic aid, electronic baropodometry can be useful in treatment, helping in the development of orthoses, insoles and footwear customized to the observed plantar load distribution[7].

Few studies in the Brazilian literature have evaluated metatarsalgia and its implications for foot pressure[5,7]. The objective of this study is to analyze the changes in the values obtained using electronic baropodometry in patients with metatarsalgia, compare these data with the literature and determine the presence of clinical correlations.

METHODS

This study was approved by the Research Ethics Committee with registration in the Brazil Platform under CAAE number: 08329619.7.0000.0093.

This is a retrospective observational study. Patients with a clinical diagnosis of metatarsalgia who underwent static electronic baropodometry were included in the study. Diagnoses and examinations were performed by a single orthopedic surgeon specialized in foot and ankle surgery, between February 2017 and June 2018, in a private medical office in the city of Curitiba, Paraná, Brazil. Static electronic baropodometry was routinely performed in all patients as part of the clinical evaluation by this surgeon after obtaining patient consent. Two patients younger than 18 years who did not undergo the baropodometry examination were excluded from the study. Based on these criteria, 39 patients were selected for the study, and clinical and imaging data were collected from electronic medical records.

All patients in this study underwent baropodometric evaluations using the same device, and the evaluations were performed by a single orthopedic surgeon specialized in foot and ankle surgery. Patients were placed on the pressure plate in a standing position, with the feet parallel and the arms hanging at the sides of the body (Figure 1). The device used was a pressure plate running FootWork Pro Analysis System version 1.1.3.0 software (AM^3, IST Informatique - Intelligence Service et Tecnique, France).

The data collected included gender, height (m), weight (kg), body mass index (BMI), laterality of the foot with metatarsalgia, shoe size and clinical diagnosis. The baropodometric variables analyzed in the static test included percent plantar load of the forefoot and rearfoot (defined as anterior and posterior to the foot center of gravity, respectively), percent plantar load of each individual foot (mean pressure of the right and left foot, KPa) and maximum plantar pressure in kgf/cm^2 (Figure 2).

All data were organized in Excel spreadsheets. Continuous variables are expressed as the mean and standard deviation and were compared using the nonparametric Wilcoxon or Mann-Whitney test. Correlation analyses were performed using Pearson's parametric correlation test[8]. Categorical variables are expressed as percentages. The statistical analyses were performed with the GraphPad Prism 7 statistical package, and a significance level of 5% (p=0.05) was adopted.

As this is a retrospective study in which only data from medical records and previously performed tests were analyzed, and because the patients were not identified at any time, informed consent was not required. A consent dispensation form was thus completed with the guidance and authorization of the ethics and research committee.

RESULTS

Data from 39 patients were analyzed, including 16 male (41.0%) and 23 female (58.9%) patients. The mean height was 1.65m, and the mean weight was 71kg. The mean BMI was 26.44. Of the total, 24 patients (61.53%) had an above-

Figure 1. Patient positioned for measurement and collection of static electronic baropodometric data.
Source: Authors' personal archive.

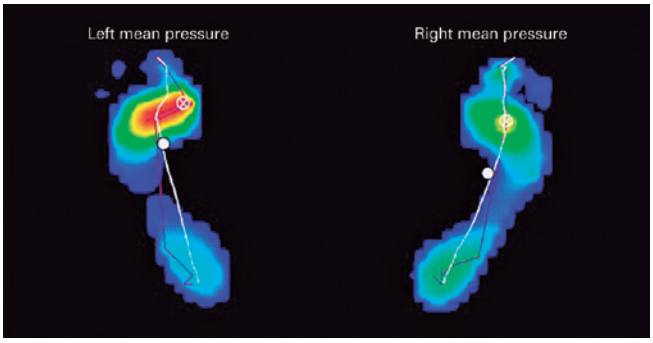

Figure 2. Example of mapping and measurements with electronic baropodometry.
Source: Authors' personal archive.

normal BMI, i.e., ≥25kg/m^2, and 5 patients (12.8%) were classified as obese, with a BMI greater than 30kg/m^2. The mean age was 50.8 years (Table 1).

Regarding the laterality, 7 (17.9%) patients presented metatarsal pain only on the right side, 5 (12.8%) patients presented pain on the left side, and 27 (69.2%) patients presented pain bilaterally. There were no significant differences between the maximum pressure ipsilateral and contralateral to the foot with metatarsalgia. The values are shown in Table 2. In the group with bilateral involvement, 44% had a higher maximum pressure value in the right foot, and 56% had a higher maximum pressure value in the left foot. No significant relationship was observed between shoe size and plantar pressure values.

The mean pressure, mean maximum pressure and mean foot load distribution values are shown in Table 3.

Table 1. Epidemiological data from medical records

	Frequency	%
Sex		
Male	16	41.02
Female	23	58.97
Age (years)		
<25	0	0
25-39	9	23.07
40-59	20	51.28
>60	10	25.64
Laterality		
Right	7	17.94
Left	5	12.82
Bilateral	27	69.23
BMI		
<18.5	0	0
18.5-24.9	15	38.46
25.0-29.9	19	48.71
>30.0	5	12.82

BMI: body mass index.
Source: Prepared by the author based on the results of the research.

Table 2. Pressure (kgf/cm^2) according to laterality

Laterality	Pressure	Contralateral pressure	*P*
Right (n=7)	1.85±0.35	1.75±0.32	0.688
Left (n=5)	1.85±0.36	2.02±0.37	0.625

Source: Prepared by the author based on the results of the research.

Table 3. Mean values obtained in the baropodometric analysis

	Value
Mean pressure (kgf/cm^2)	
Right	0.53
Left	0.57
Overall	0.55
Maximum pressure (kgf/cm^2)	
Right	1.82
Left	1.7
Overall	1.76
Load distribution (%)	
Forefoot	46.3
Rearfoot	53.6
Forefoot-to-rearfoot ratio	0.86

Source: Prepared by the author based on the results of the research.

Correlation analysis was performed between the BMI and maximum pressure on each foot. A significant association (p=0.001) was observed when analyzing the data from the left foot. No significant association was observed for the right foot (p=0.015). The mean maximum plantar

pressure for the group of obese patients was 2.051kgf/cm^2, whereas the overall mean was 1.76kgf/cm^2. Our analysis indicates a directly proportional relationship between BMI and maximum pressure.

DISCUSSION

Metatarsalgia is a clinical condition that involves plantar pain under the metatarsal heads. The expected normal body response in this condition is to avoid increasing the pressure in these painful areas, which leads to an increase in the load on other foot regions[9]. Wafai et al.[10] found that painful symptoms in the foot lead to plantar pressure asymmetry, and the quantification of this asymmetry by baropodometry may be useful in the identification and diagnosis of pathologies. Some studies have evaluated the load distribution between the forefoot and rearfoot in normal individuals[11,12]. Birtane et al.[11] found a forefoot-to-rearfoot load distribution ratio of 1.03 in nonobese individuals. Lalande et al.[12] obtained a ratio of 0.93 when evaluating healthy individuals. The forefoot-to-rearfoot ratio found in our study was 0.83. This small difference may be explained by a natural tendency of the metatarsalgia patients included in our study to decrease the load on the forefoot as a proprioceptive mechanism to reduce pain, consequently increasing the load on the rearfoot.

Similar to our study, Martin et al.[13] evaluated the load distribution in 100 individuals with metatarsalgia. They found that 45.8% of the load was transmitted to the forefoot, and 54.2% was transmitted to the rearfoot. These values are very similar to those obtained in our study, which reinforces the finding that patients with metatarsal pain tend to increase the load on the rearfoot.

An association between obesity and pain and discomfort in the feet has previously been established in the literature. This symptomatology has a negative effect on the quality of life[14,15]. From the baropodometric perspective, Fabris et al.[16] found a general increase in the maximum plantar pressure in the obese population, with a mean of 0.894kgf/cm^2 and prevalent load distribution to the forefoot. In the same study, the population control group, which had a BMI considered normal, had a mean maximum plantar pressure of 0.636kgf/cm^2 and prevalent load on the rearfoot. This increased maximum pressure in the obese patient group was also observed in our study.

As a result of the increased load and its relationship with metatarsalgia and other foot complaints, especially during physical activity, the obese population suffers from the following dilemma: how can weight loss be accomplished if the practice of many physical activities leads to pain? To achieve weight loss, in addition to diet control, the practice of nonimpact physical activities without load should be encouraged in this population[14, 17].

The treatment of metatarsalgia with the use of metatarsal insoles is a low-cost and efficient method to relieve symptoms[18]. These insoles are best positioned immediately proximal to the metatarsal head[18,19]. Some studies[19,20] have evaluated the effect of the use of insoles on the pressure exerted on the foot using baropodometry and concluded that correct insole positioning leads to a decrease in the maximum pressure on the metatarsal head, with load redistribution occurring proximally.

The use of customized orthoses for the treatment of metatarsalgia led to a significant improvement in symptoms and a reduction of plantar pressure[21]. Poon et al.[3] also advocated the use of baropodometry to assist in the development of custom orthoses, which was effective in the control of symptoms. Regarding the type of footwear used by patients with metatarsalgia, it should preferably be comfortable and have a wide and high anterior chamber and thick soles. Schuh et al.[22] demonstrated the effectiveness of custom-made sandals in patients with metatarsal pain; improved walking times and distances were achieved when the sandals were used. Shoes with curved soles may also be useful for relieving symptoms during walking[23].

Our study has some limitations. The use of an asymptomatic control group and the separation of groups according to the presence of metatarsalgia could strengthen the comparative analysis. Another limiting factor is the low number of patients in the sample. Additional studies with a greater number of participants, the use of a control group for comparison and prospective analysis could provide new and relevant information about the topic.

CONCLUSION

The values obtained in our analysis were consistent with those found in the literature. In our study, obese and overweight patients had higher maximum plantar pressure values and greater load distribution to the forefoot. However, based on the data of our study, we cannot determine the relationship between being overweight and having metatarsalgia. Therefore, it is important to consider the possible increased risk in this population. We suggest that further studies with comparative control groups and prospective assessment should be conducted.

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