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PREVALENCE OF DIABETIC FOOT-RELATED DEFORMITIES AND ASSOCIATED FACTORS IN PEOPLE WITH DIABETES MELLITUS

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ABSTRACT

The objective of this study is to identify the frequency of osteoarticular deformities in the feet and their association with the risk for ulceration and reulceration in people with diabetes mellitus. This is a cross-sectional study carried out among individuals under monitoring at the State Reference Center for Diabetes Care and Endocrinology of Bahia, from November 2006 to February 2018. Descriptive analysis and calculation of prevalence ratios were performed to verify the association between deformities and risk for ulceration.The results showed that among the 309 study participants, 117(37.9%) had osteoarticular deformities, with those located in the forefoot being the most prevalent (36.9%). It was observed that patients with deformities had a higher proportion of risk categories for ulceration when compared to those without deformities (PR=1.99; 95% CI = 1.27-3.11; p= 0.002). The association between foot deformities and risk categories for ulceration highlights the importance of preventive measures to reduce the occurrence of amputations among people with diabetes.

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INTRODUCTION

Diabetic Foot (DF) is defined by the International Working Group on the Diabetic Foot – IWGDF (Apelqvist *et al.,* 2020), such as the occurrence of ulceration, infection or destruction of deep tissues, as a result of neuropathy and/or peripheral arterial obstructive disease (PAOD) in the lower limbs in people with diabetes mellitus (DM). DF is the main cause of non-traumatic amputation worldwide and occurs most commonly due to neurological changes (Brasil, 2016). Arteriopathy alone can cause complications, but this occurs in only 10% of cases. About 25 to 45% of individuals with DF have concomitant presentation of neuropathy and angiopathy. Infection, in turn, participates in the process as an aggravating factor for ulcers, increasing the risk of complication (Monteiro-Soares *et al.,* 2019; Duarte and Gonçalves (2011). It is known that, once the ulcer is established, there is a great risk of progression to mutilation, since these precede lower limb amputations in diabetics in up to 85% of cases (Brasil, 2016). Neuropathy can manifest itself in three different ways: sensory, motor, and autonomic. Sensory neuropathy determines the loss of painful sensation, which acts as a protective mechanism. This makes the feet more susceptible to the development of injuries secondary to repetitive trauma, usually caused by the use of shoesunsuitable for the anatomy of the foot, or by the inadvertent penetration of sharp objects in the extremity (Lopes unpublished 2011). In autonomic neuropathy, the scarcity or absence of sweat production has repercussions on the hydration of the distal extremities, which are more conducive to the appearance of fissures and cracks in the skin, sensitive to bacterial penetration and the establishment of ulcerations and infections (Monteiro-Soares *et al.,* 2019). In motor neuropathy, there is an impact on muscle activity due to the weakening and atrophy of the intrinsic muscles of the foot, in addition to the impairment of joint mobility, which occurs due to the glycation of proteins in the articular connective tissue. Together, these changes generate an imbalance of forces between the flexor and extensor muscles in the feet, which determines the formation of osteoarticular deformities – claw fingers and hammer toes (Lopes *unpublished,* 2011). These deformities, when subjected repetitively to stresses resulting from orthostatic and ambulation, cause increased pressure at some points, resulting in calluses, which can be precursors to the development of ulcers, when there is associated sensory neuropathy (Monteiro-Soares *et al.,* 2019; Lopes *unpublished,* 2011). Deformities are more prevalent in the forefoot because this region plays a key role in the plantar support and heel propulsion phases, accounting for 30% to 40% of activity during a gait cycle (Dragan *et*

al., 2019). Thus, the work overload on this area of the foot determines that it is the most compromised by motor neuropathy, being prone to present a higher percentage of osteoarticular deformities, when compared to the hindfoot (Duarte and Gonçalves, 2011; Lopes *unpublished* 2011; Dragan *et al.,* 2019; Lazaro-Martinez *et al.,* 2014). The higher prevalence of forefoot deformities results in a greater number of ulcerations in this region as well (Monteiro-Soares *et al.,* 2019; Molines-Barroso, 2016). The risk for foot ulceration with loss of protective sensitivity increases from 1.7 to 12.1 when there is the concomitant presence of osteoarticular deformities, and progresses to 36.4, with previous amputation or ulcer (Lavery, 1998). Thus, osteoarticular deformities, when present in a foot with loss of plantar protective sensation, have great relevance for the risk of ulceration and amputation, so that new technologies have been used to measure this risk factor (Zhao *et al.,* 2017; Lu *et al.,* 2015; Najafi *et al.,* 2017. The monitoring and management of these changes by the nursing team should be carried out with a view to providing guidance on self-care measures and proposing appropriate interventions on the main biomechanical parameters of risk for ulceration, as one of the strategies for reducing amputations in the population of DM patients. The objective of this article is to describe the prevalence of osteoarticular deformities in the feet and to associate them with the risk categories for ulceration and reulceration related to the diabetic foot of people monitored at a center specialized in the treatment of diabetes mellitus.

METHODS

Ethical aspects: The study followed the recommendations of Resolution number 466/2012 of the National Health Council. It was approved by the Research Ethics Committee of the College of Medicine of the Federal University of Bahia and conducted according to the required ethical standards.

Study design, period and place: This is a cross-sectional study, based on primary data extracted from a cohort of individuals monitored at the Bahia State Reference Center for Diabetes Care and Endocrinology (CEDEBA), from November 2006 to February 2008. Such data were obtained from the first visit of each patient. The guidelines of *the Strengthening the Reporting of Observational Studies in Epidemiology* (STROBE) were followed to organize the study.

Population: The study sample consisted of 309 patients monitored at the diabetic foot outpatient clinic of CEDEBA, diagnosed with type 2 DM, aged 18 years or older and without active foot ulcer. The following exclusion criteria were established: to be a carrier of ischemia, characterized by the presence of an ankle-brachial index (ABI) ≤ 0.8 mmHg; to present amputation above the level of the unilateral or bilateral medium-tension of the lower limbs; to be a carrier of cognitive and/or language deficit that prevented verbal communication; and pregnancy.

Study protocol: The individuals studied were included consecutively during their regular outpatient monitoring in the unit. Sociodemographic and clinical data were collected through a semi-structured questionnaire. The physical examination followed the following stages: inspection, palpation of the distal pulses of the lower limbs, application of the 10g monofilament test and measurement of the ABI. The sociodemographic variables of interest were age, sex, education and family income. Age was categorized into three age groups: from 26 to 40 years, from 41 to 59 years and greater than or equal to 60 years. Schooling was defined by the completion of high school, being categorized as not complete and complete. Income was categorized as less than or equal to two or greater than two minimum wages, using the reference value of the minimum wage in the current year. As for the clinical variables, the time of DM treatment in years was recorded, being categorized into ≤ 10 and > 10 years; and the difficulty of wearing/putting on shoes. The variable osteoarticular deformities, when present, was defined as single or multiple (≥2). At least one of the following changes was considered: 1st toe bunion, 5th toe bunion, claw/hammer fingers, midfoot prominence, forefoot prominence, overlapping fingers, previous toe amputation. The bilateral presence of the same type of deformity was not considered as multiple deformity. The outcome variable – risk of ulceration or reulceration (RU) – was defined during foot examination and categorized according to the adaptation of the IWGDF risk classification in grade 0–protective sensitivity present; grade 1– loss of protective sensitivity, without osteoarticular deformities; grade 2– loss of protective sensitivity, with osteoarticular deformities; grade 3– history of previous ulcer or amputation. Patients classified as grade 1, 2 or 3 were considered at risk of ulceration and reulceration, while patients classified as grade 0 were considered at no risk.

Analysis of results and statistics: Data were tabulated in Microsoft Excel for Windows® and analyzed in the Stata statistical package (V.12.0), where corrections and elimination of inconsistencies were performed. Descriptive analysis identified characteristics of the population with calculation of means and proportions. The chi-square technique was used to study categorical variables. The magnitude of the association under investigation was estimated by calculating the prevalence ratios (PR), adopting the 95% confidence interval (95% CI) and determining the p values.

RESULTS

The study population consisted of 309 individuals, with a mean age of 57 years (±9.2), and a predominance of people aged between 41 and 60 years (64.1%). There was a higher proportion of females (65.0%), non-white people (83.9%), people with education up to elementary school (73.1%), and people living with a family income of up to two minimum wages (73.5%). Most individuals (60.7%) reported a diagnosis of DM more than 10 years ago. Just over half of respondents (50.7%) reported difficulty wearing/putting on shoes. Osteoarticular deformities in the feet were detected in 117 patients (37.9%), and 57 (48.7%) and 60 (51.3%) had single and multiple deformities, respectively. The 5th toe bunion and forefoot prominence were the most frequently found alterations, corresponding to 20.4% and 15.9%, respectively.

Table 1. Sociodemographic and clinical characteristics of individuals with diabetes mellitus monitored at the diabetic foot outpatient clinic of the State Reference Center for Diabetes Care and Endocrinology of Bahia. Salvador, Bahia, 2006-2008. (n=309)

Variables	n (%)	Patients with deformities (prevalence)	Patients without deformities
Gender			
Female	201 (65)	73 (36.3%)	128
Male	108 (35)	44 (40.7%)	64
Age (years)			
≥ 26 e ≤ 40	7 (2.3)	1 (14.3%)	6
> 40 e ≤ 60	198 (64.1)	82 (41.4%)	116
>60	104 (33.7)	34 (32.7%)	70
Skin color			
White	49 (16.1)	18 (36.7%)	31
Non-white	256 (83.9)	99 (38.7%)	157
Income (wages)			
≤ 2	227 (76.9)	86 (37.9%)	141
> 2	68 (23.1)	27 (39.7%)	41
Education			
< 8 years	208 (67.3)	75 (36.1%)	133
≥ 8 years	101 (32.7)	42 (41.6%)	59
Diabetes mellitus time (years)	121 (39.3)	48 (39.7%)	73
≤ 10	187 (60.7)	69 (36.9%)	118
> 10			
Difficulty wearing shoes			
No	152 (49.5)	60 (39.5%)	92
Yes	156 (50.7)	57 (36.5%)	99

The other deformities: 1st toe bunion, claw/hammer fingers, midfoot prominence, overlapping fingers and previous toe amputation had a frequency of less than 10%. Patients over 40 years of age had a frequency of deformities 2 to 3 times higher than patients in the age group ≤ 40. No differences in proportion were observed between the other sociodemographic/ clinical variables and deformities (Table 1).

Table 2. Prevalence of risk category for ulceration and reulceration by type of deformity among individuals with diabetes mellitus monitored at the diabetic foot outpatient clinic of the State Reference Center for Diabetes Care and Endocrinology of Bahia. Salvador, Bahia, 2006-2008. (n=309)

Deformities	n (%)	Risk of ulceration or reulceration (%)	Prevalence ratio	P-value
Absent	192 (62.1)	14.8		
All	117 (37.9)	29.5	1.99	0.002
Multiple	60 (51.3)	20.3	1.37	0.988
Clawed/hammeredtoes	27 (8.7)	33.3	2.25	0.097
Overlapping toes	8 (2.6)	37.5	2.53	0.219
1st toe bunion	29 (9.4)	17.2	1.16	0.670
5th toe bunion	63 (20.4)	27.9	1.89	0.098
Forefootprominence	49 (15.9)	38.3	2.59	0.001
Midfoot prominence	3 (1.0)	50.0	3.38	0.294
Previous amputation– toes	20 (6.5)	64.7	4.37	< 0.001

Table 2 shows the data on the prevalence of RU, according to the presence of deformities. In the group of non-carriers of osteoarticular deformities, the proportion of people in the RU is lower (14.8%) in relation to the total population (19.8%). In the group of deformity carriers, the prevalence of people in the RU reaches 29.5%, being even higher among those who have toe amputation alone (64.7%). There was a difference in proportion between the groups, with patients with deformities presenting twice the frequency of the outcome when compared to patients without deformities (PR = 1.99; 95% CI = 1.27-3.11; p = 0.002).

DISCUSSION

The frequency of deformities was compatible with the results of national studies carried out in specialized care services (Dutra *et al*., 2018; Guimarães unpublished 2011; Vidal unpublished 2009). The high prevalence in these populations is due to the selection of patients in reference outpatient clinics, possibly referred with advanced disease, requiring specialized evaluation, which does not occur, for example, in Family Health Units (FHU), where the frequency of deformities is around 12.5% (Bezerra *et al.,* 2015). No studies were identified in which all types of DF-related deformities were aggregated in a single study. However, as evidenced in this work, in international studies (Fernando *et al.,* 2016; Arts *et al.,* 2012) there is a predominance of deformities in the forefoot, which is compatible with an association between the mechanisms of diabetic neuropathy and the biomechanical conditions imposed on this region during gait (Arts *et al.,* 2012; Silva *et al.,* 2017). The higher frequency of osteoarticular deformities among those over 40 years of age demonstrates compatibility with the pathophysiological mechanism in motor neuropathy, in which the succession of events triggering the deformities occurs over the years after the establishment of DM (Monteiro-Soares *et al.,* 2019). This period, however, should not be associated with the time of diagnosis of DM, since, in most cases, the diagnosis of the disease is made long after its establishment. This is because type 2 DM has an insidious onset and, frequently, the diagnostic suspicion is raised only in the face of late complications (Brasil 2013).

The presence of deformities was associated with the risk categories for ulceration and reulceration proposed by the IWGDF, which is compatible with the knowledge already well-established in the guidelines on diabetic foot. Osteoarticular deformities are known to be among the main risk factors for ulcer development, along with loss of protective sensitivity and peripheral arterial disease (Monteiro-Soares *et al.,* 2019; Dutra 2018). It isworth mentioning the fact that, in the present study, almost half of the patients presented multiple deformities, which are in a greater proportion among the individuals categorized as at risk of ulceration, which can be justified by the cumulative effect of pressure in more than one prominent point (Monteiro-Soares *et al.*, 2019).

It is understood that the impact of deformities in the causal network of lower limb amputations can be minimized by establishing early interventions, whether aimed at prevention, treatment and/or rehabilitation, including measures to reduce plantar pressure, both conservative and surgical (Fernando *et al.,* 2016; Arts *et al.*, 2012). Among the preventive interventions/ actions available, we highlight the use of insoles that reduce pressure points generated by deformities and suitable shoes, which can be shaped and adapted to the anatomical characteristics of the individuals' feet. In addition, actions sensitive to primary health care (PHC) should be encouraged, such as the development of Health Education practices for patients and their peers, through the provision of guidelines for daily life, in order to promote improvement in self-care, daily inspection of the feet and recognition of changes that may constitute alarm signals. Thus, continuous monitoring with a health team trained to recognize risk conditions in the context of diabetic foot, as well as prompt preventive or therapeutic intervention in the management of deformities, is one of the pillars of amputation prevention among DM patients (Brasil 2016; Bus *et al.,* 2020; Fernando *et al.,* 2016; Brasil 2013; Smanioto *et al.,* 2014; Van Netten *et al.,* 2016; Lucoveis *et al.,* 2018; Galdino *et al.,* 2019; Bus *et al.,* 2015; López-Moral *et al.,* 2019; Igiri *et al.,* 2019).

Study limitations: As this is a public care service, in which most patients have low purchasing power and education, the homogeneity of this population may have contributed to the fact that no associations were found between these sociodemographic variables and the presence of deformities.

Contributions to the field of health: The present study demonstrates a higher proportion of individuals with osteoarticular deformities in the feet, among those identified as at risk for ulceration, which reinforces the need for an active posture of the multidisciplinary health team in search of this type of foot alteration, aiming at the early establishment of interventions.

CONCLUSIONS

The results of this investigation suggest that the prevalence of osteoarticular deformities in the feet is high and this alteration is associated with a higher risk status for ulceration and reulceration among individuals with DM monitored at CEDEBA. The analysis of the factors associated with the degrees of risk for ulceration in individuals with diabetes in the proposed perspective has the potential to contribute to the expansion of the offer of interventions that favor the reduction of morbidity related to diabetic foot. In this sense, it is understood that new research with greater analytical power should be encouraged to investigate the role that each type of deformity, individually and together, plays on the development of ulcers, in order to increase the impact of health actions currently implemented in the face of the needs of this population, with the objective of reducing the lower limb amputation rates, which will directly impact the lives of individuals and the health system.

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