

PREVENTION OF DIABETIC FOOT DISEASE: CLINICAL PROFILE AND ASSOCIATED FACTORS

PREVENÇÃO DA DOENÇA DO PÉ RELACIONADA AO DIABETES MELLITUS: PERFIL CLÍNICO E FATORES ASSOCIADOS

PREVENCIÓN DE LA ENFERMEDAD DEL PIE RELACIONADA CON LA DIABETES MELLITUS: PERFIL CLÍNICO Y FACTORES ASOCIADOS



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ABSTRACT

Considering the high incidence and magnitude of Diabetes Mellitus and its chronic complications, especially Diabetes-Related Foot Disease (DRFD), which presents high rates of ulceration, amputation, and healthcare costs, the need for screening and prevention strategies based on early identification of risk factors becomes evident. This study aims to identify the sociodemographic and clinical profile, evaluate associated risk factors, and provide guidance to patients regarding the prevention of foot complications. To this end, an observational, analytical, descriptive, and cross-sectional study was conducted with 50 patients with type 2 diabetes receiving outpatient care. Data were collected through a semi-structured questionnaire, clinical foot inspection, neurological tests (monofilament, tuning fork, Achilles reflex), vascular assessment by pulse palpation and ankle-brachial index measurement, in addition to inferential statistical analysis. Thus, a high frequency of inadequate BMI, sedentary lifestyle, hypertension, and dyslipidemia was observed, as well as dermatological, neuropathic, and vascular alterations in the feet, with significant association between clinical findings and ankle-brachial index changes. It is concluded that systematized anamnesis combined with clinical examination and risk stratification constitutes an essential tool for preventing ulcerations and amputations, reinforcing the importance of health education and periodic follow-up.

Keywords: Diabetes Mellitus. Complications. Self-Care. Diabetic Foot. Risk Factors.

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RESUMO

Ao considerar a elevada incidência e a magnitude do Diabetes Mellitus e suas complicações crônicas, especialmente a Doença dos Pés Relacionada ao Diabetes Mellitus (DPRDM), que apresenta altas taxas de ulceração, amputação e custos ao sistema de saúde, evidencia-se a necessidade de estratégias de rastreamento e prevenção baseadas na identificação precoce de fatores de risco. Objetiva-se identificar o perfil sociodemográfico e clínico, avaliar fatores de risco associados e orientar pacientes quanto à prevenção de complicações nos pés. Para tanto, procede-se a um estudo observacional, analítico, descritivo e transversal, realizado com 50 pacientes com DM2 em atendimento ambulatorial, mediante aplicação de questionário semiestruturado, inspeção clínica dos pés, testes neurológicos (monofilamento, diapasão, reflexo aquileu), avaliação vascular por palpação de pulsos e cálculo do índice tornozelo-braquial, além de análise estatística inferencial. Desse modo, observa-se elevada frequência de IMC inadequado, sedentarismo, hipertensão e dislipidemia, bem como alterações dermatológicas, neuropáticas e vasculares nos pés, com associação significativa entre achados clínicos e alterações no índice tornozelo-braquial. Conclui-se que a anamnese sistematizada aliada ao exame clínico e à estratificação de risco constitui ferramenta essencial para prevenção de ulcerações e amputações, reforçando a importância da educação em saúde e do acompanhamento periódico.

Palavras-chave: Diabetes Mellitus. Complicações. Autocuidado. Pé Diabético. Fatores de Risco.

RESUMEN

Considerando la elevada incidencia y magnitud de la Diabetes Mellitus y sus complicaciones crónicas, especialmente la Enfermedad del Pie Relacionada con la Diabetes Mellitus (EPRDM), que presenta altas tasas de ulceración, amputación y costos para el sistema de salud, se evidencia la necesidad de estrategias de tamizaje y prevención basadas en la identificación precoz de factores de riesgo. Se objetiva identificar el perfil sociodemográfico y clínico, evaluar factores de riesgo asociados y orientar a los pacientes sobre la prevención de complicaciones en los pies. Para ello, se realizó un estudio observacional, analítico, descriptivo y transversal, con 50 pacientes con DM2 en atención ambulatoria, mediante la aplicación de un cuestionario semiestructurado, inspección clínica de los pies, pruebas neurológicas (monofilamento, diapasón, reflejo aquileo), evaluación vascular por palpación de pulsos y cálculo del índice tobillo-braquial, además de análisis estadístico inferencial. De este modo, se observó alta frecuencia de IMC inadecuado, sedentarismo, hipertensión y dislipidemia, así como alteraciones dermatológicas, neuropáticas y vasculares en los pies, con asociación significativa entre los hallazgos clínicos y las alteraciones del índice tobillo-braquial. Se concluye que la anamnesis sistematizada, asociada al examen clínico y a la estratificación de riesgo, constituye una herramienta esencial para la prevención de ulceraciones y amputaciones, reforzando la importancia de la educación en salud y del seguimiento periódico.

Palabras clave: Diabetes Mellitus. Complicaciones. Autocuidado. Pie Diabético. Factores de Riesgo.

1 INTRODUCTION

Diabetes Mellitus (DM) is a chronic metabolic disease characterized by persistent hyperglycemia that results from a deficient secretion of insulin by pancreatic beta cells, peripheral resistance to insulin action, or in some cases a combination of both. Estimates from the World Health Organization (WHO) indicate that one in twelve people has DM, in addition, in 2024 according to data from the *International Diabetes Federation* (IDF) the mark of 589 million people with the diagnosis was reached (VILAR, 2020; INTERNATIONAL DIABETES FEDERATION, 2024).

Projections for 2050 indicate that South America will go from the current 35.4 million patients to 51.5 million; in addition, Brazil currently has approximately 16.6 million patients, occupying the 6th place in the world ranking and that in the year 2050 will move to 7th position, however it is estimated that there will be 24 million people diagnosed in the country (VILAR, 2020; INTERNATIONAL DIABETES FEDERATION, 2024).

In type 1 diabetes mellitus (DM1) there is an absolute deficiency of insulin due to autoimmune or idiopathic destruction, that is, without a specific cause of the pancreatic beta cells. Type 2 Diabetes Mellitus (DM2) is associated with peripheral resistance to insulin action on adipocytes and skeletal muscle, deficient insulin secretion by the pancreas, or even increased hepatic glucose production, resulting from insulin resistance in the liver (VILAR, 2020).

T2DM can manifest classic symptoms such as polyuria, polydipsia, polyphagia, and weight loss, but up to 50% of patients are asymptomatic or have nonspecific symptoms such as dizziness and fatigue. The most relevant risk factors for the development of T2DM include obesity, present in about 80% of cases, sedentary lifestyle, family history, race/ethnicity, age >45 years, hypertension, polycystic ovary syndrome, smoking, and dyslipidemia. Diagnosis requires two abnormal results in fasting glucose, glycated hemoglobin or Oral Glucose Tolerance Test (OGTT), with glycated hemoglobin being the main parameter for glycemic control (AMERICAN DIABETES ASSOCIATION, 2024).

According to the Brazilian Diabetes Society (SBD), for the diagnosis of DM2, Fasting Glucose (FPG) ≥ 126 mg/dl, Glycated Hemoglobin (HbA1c) $\geq 6.5\%$, TTGO-1h ≥ 209 mg/dl, TTGO-2h ≥ 200 mg/dl) are considered diagnostic criteria for the diagnosis of Diabetes Mellitus, however the presence of 2 altered diagnostic tests within these is recommended. To prevent micro- and macrovascular complications, the treatment of DM involves strict glycemic control, in addition to lipid control and blood pressure. The ideal fasting glucose targets are between 80 and 130 mg/dl and postprandial below 180 mg/dl (RODACKI *et al.*, 2024).

Therapeutic approaches include lifestyle changes, such as diet, exercise, weight loss, and smoking cessation, as well as the use of hypoglycemic medications, such as antidiabetics and insulins, depending on the severity and type of DM. If not treated properly, chronic hyperglycemia can result in progressive damage to organs and tissues, leading to a series of debilitating complications (VILAR, 2020; RODACKI *et al.*, 2024).

In addition to the types of DM mentioned above, there are other rarer forms of DM such as gestational DM (DMG) (WORLD HEALTH ORGANIZATION, 2023), *Latent Autoimmune Diabetes in Adults* – LADA, which is a hybrid between DM1 and DM2 usually diagnosed in adulthood (RODACKI *et al.*, 2022), *Maturity-Onset Diabetes of the Young* – MODY, also called monogenic diabetes due to its etiology coming from a specific gene (NATARAJAN *et al.*, 2023), the newly classified type 5 DM most common in low-income countries, resulting from pancreatic underdevelopment due to malnutrition (INTERNATIONAL DIABETES FEDERATION, 2025), among other less incident forms of DM.

Complications of T2DM include microvascular damage, such as retinopathy, nephropathy, and diabetic neuropathy, which can lead to blindness, chronic kidney disease, and peripheral nerve damage. Macrovascular complications, on the other hand, include cardiovascular diseases, such as coronary artery disease and stroke (INTERNATIONAL DIABETES FEDERATION, 2024)

Diabetes Mellitus-Related Foot Disease (DPRDM) is a specific complication that associates neurological abnormalities with vascular disease of the lower limbs. Peripheral neuropathy is characterized by the loss of sensitivity of the feet, a fact that can result in the non-perception of lesions, which generates serious infections and possible amputations. In addition, the patient has vascular disease, with a change in blood circulation, which means that the healing of lesions is impaired. These changes result in a 25 times higher risk of amputation compared to healthy people, making it the main cause of non-traumatic amputation of the lower limbs (CARVALHO NETO, 2022).

Ulcerations in the feet of patients with diabetes (UPD) precede more than 80% of amputations, promoting a worsening of the patient's quality of life due to the personal impact, and high costs for the health system, since it lacks prolonged hospital treatment, being a costly condition generating expenses with procedures, hospital admissions, treatment and rehabilitation (LO *et al.*, 2021). In Brazil, the annual medical costs associated with DPRDM were estimated at approximately 361 million dollars, from the hospital and surgical spheres to outpatient treatment, showing the importance of this condition and its magnitude in relation to the Unified Health System (SUS) (TOSCANO *et al.*, 2018).

Prolonged exposure to hyperglycemia damages fine nerve fibers, reducing sensitivity and causing xeroderma. In advanced stages, it also affects the large fibers, resulting in structural deformities in the feet, loss of proprioception, reaching muscle weakness and changes in bone architecture. Deformities such as claw fingers, metatarsal prominences, and enlargement of the plantar arch generate areas of abnormal pressure, altering gait and favoring injuries. External trauma, such as inappropriate footwear and falls, are responsible for 80 to 90% of UPD. In addition, the decrease or absence of sweating can dry out the skin, predisposing cracks and fissures, which, associated with preulcerative lesions, can cause ulcers if there is no timely intervention (BURIHAN *et al.*, 2020).

The history of the disease associated with the patient's comorbidities, and a complete clinical examination are crucial for early diagnosis and risk classification for UPD, and involve simple, low-cost, and well-accurate neurological and vascular tests, which, if done properly and systematically, would drastically reduce the cases of complications and amputations. A multicenter study of patients with T2DM in Brazil found that only 58% of those treated in specialized and non-specialized centers had a record of foot examination performed in 2020 (BURIHAN, 2020).

Thus, it is crucial that patients at higher risk of ulceration are identified early and referred to preventive treatment. For this, the ideal is that an exam with inspection and clinical examination be carried out for all patients with DM classified as *International Working Group on the Diabetic Foot*. The IWGDF risk stratification scale for the development of DPRDM stratifies patients according to their risk of developing this condition with the periodicity necessary for prevention, as follows: 0 – very low risk (there is no evidence of LOPS or PAD, with annual evaluation), 1 – low risk (LOPS or PAD alone with evaluation between 6-12 months), 2 – moderate risk (LOPS and PAD associated, or one of them associated with deformities, between 3-6 months), 3 – high risk (LOPS or PAD associated with: ulcerative history, previous amputation or end-stage renal disease; evaluated between 1-3 months) (BUS *et al.*, 2024; IWGDF, 2023).

The IWGDF recommends that the neurological evaluation of the feet in people with DM2 include, as a priority, the 10 g monofilament test to detect the loss of protective sensation and the 128 Hz tuning fork test to evaluate vibratory sensitivity. This exam can be complemented with light touch tests, pain test (*pinprick*) and evaluation of the Tendinimum-Aquilean reflex, providing the characterization and stratification of the severity of the Diabetic Neuropathy (DN) condition. These tests are essential for stratification of the risk of ulceration and amputation in individuals with diabetes. Prevention begins with identifying individuals at risk. Tracking these factors contributes to awareness and early detection of preulcerative

signs, preventing future complications. In addition to being feasible and accessible, this screening does not pose any risks to the patient (BUS *et al.*, 2024).

That said, training health professionals for efficient triage, and educating patients and families for self-care are essential to prevent DPRDM and its complications. Data obtained from controlled groups showed that 1 hour of education reduces amputation rates by 70% over a two-year period. In order to achieve good results, the way forward is: identify the foot at risk, regularly inspect and examine this limb, educate the patient, family, and health professionals, ensuring good self-care, and treat associated risk factors for possible ulcerations (BURIHAN, 2020).

In view of the contexts exposed, it is clear the importance of a complete approach to the patient, considering associated risk factors and a thorough physical examination, through different neurological and vascular tests, in order to stratify the patient's risk, make him aware of this risk and prevent ulcerations. In addition, promoting good education of patients and their families about the severity of the disease and what daily care should be taken to avoid complications has been shown to be a good preventive resource.

Thus, the research question arises: Does the complete anamnesis, systematized clinical examination and the associated risk factors identified help in the prevention of Foot Disease Related to Type 2 Diabetes Mellitus? The hypothesis of the study is that it is possible to prevent the appearance of foot ulcers in patients with diabetes mellitus through risk stratification guided by a complete anamnesis, systematized clinical examination and identified risk factors. Therefore, the objectives of the study are to identify the sociodemographic and clinical profile, evaluate the associated risk factors and provide guidance on complications of the disease, to prevent foot ulcers in diabetic patients in outpatient care.

2 METHODOLOGY

This is an observational, analytical, descriptive and cross-sectional study, carried out at the Endocrinology Outpatient Clinic of the University Hospital School Clinic, from October 2023 to October 2024. This study complied with Resolution No. 466, of December 12, 2012, National Health Council – CNS, which deals with ethics in research involving human beings, with approval by the Research Ethics Committee (CEP) of the University of Vale do Sapucaí (UNIVÁS) with substantiated opinion No. 6.578.562 and CAAE No. 75372723.7.0000.5102. We included 50 patients diagnosed with DM2, both genders, aged 18 years \geq years and who signed the Informed Consent Form (ICF) and agreed to participate.

Data collection was applied to a semi-structured questionnaire that assessed: gender,

age, weight, height, occupation, lifestyle habits, family history, previous comorbidities, and time of diagnosis, whether or not there is therapeutic adherence, and whether there is a previous history of ulcers or amputations. In addition, the inspection of the feet evaluated: anatomy of the foot, deformities (increased prominences of the metatarsals, claw toes, hammertoes, bunions, and Charcot's Arthropathy); hydration (fissures and xeroderma); coloring; temperature; hair distribution; integrity of nails and skin (dermatophytosis, tinea, onychomycosis, adequate cut, calluses), among other findings. Afterwards, neurological tests were performed to evaluate vibratory sensitivity with a tuning fork of 128 Hz; the method of evaluating tactile sensitivity with the 10-gram monofilament of Semmes Weinstein, applied three consecutive times; evaluation of the Achilles tendon reflex, palpation of pulses and, at the end, the performance of the Ankle-Brachial Index (ABI). After the evaluations, an educational pamphlet was distributed, developed in an illustrative way, to guide patients, promoting the prevention of complications.

After data collection, they were tabulated in Microsoft Excel 365 and submitted to statistical analysis, quantitative variables were classified by measures of central tendency and for categorical variables, absolute and relative frequency. Data analysis was performed using the Statistical Package for the Social Sciences, Inc. (SPSS) Chicago, USA, version 28.0. The level of significance used as a criterion for acceptance or rejection in the statistical tests is 5% ($p < 0.05$). The data are presented as mean \pm standard deviation when variables are in normal distribution, or median and interquartile range if the distribution of the variable is non-normal. Comparisons between the groups were used using the Mann-Whitney, Kruskal-Wallis and Pairwise Method tests, according to the classification of the variables. The theoretical framework in a study comprises a critical and organized analysis of the literature pertinent to the theme, providing a theoretical contextualization and defining the key concepts. It should comprehensively contain previous theories, models, and research, identifying gaps, contradictions, and consensuses in the literature that are important to the focus of the work being developed.

3 RESULTS AND DISCUSSIONS

The sample consisted of 50 patients with DM2, selected according to the inclusion criteria, and data collection only began after reading and signing the Informed Consent Form (ICF).

Table 1 presents the sociodemographic, clinical, and lifestyle characteristics of the participant. The variables analyzed were gender, body mass index, physical activity, smoking, alcoholism, presence of associated comorbidities, history of foot complications,

and the number of classes of medications used in the treatment. These data allow the clinical and behavioral profile of the participants to be traced, enabling the identification of associated risk factors and relevant conditions for the monitoring and prevention of complications related to the disease.

Table 1

Sociodemographic, clinical, and lifestyle data of patients with DM2

GENDER	Frequency	Percentage %
Women	31	62
Male	19	38
N=	50	
BMI		
Suitable	4	8
Inadequate	46	92
N=	50	
SEDENTARY LIFESTYLE		
Yes	34	68
No	16	32
N=	50	
SMOKER		
Yes	20	40
No	30	60
N=	50	
DRINKER		
Yes	16	32
No	34	68
N=	50	
HAS		
Yes	41	82
No	9	18
N=	50	
DYSLIPIDEMIC		
Yes	23	46
No	27	54
N=	50	
OBESE		
Yes	13	26
No	37	74
N=	50	
THERAPEUTIC CLASS OF TREATMENT		
1 class	27	54
2 classes	14	28
3 classes	9	18
N=	50	
HISTORY		
Previous ulcerations	5	11,36
Previous Amputations	3	6,82
No	36	81,82
N=	44	
*=	6	
OTHERS		
Yes	12	24
No	38	76
N=	50	

BMI Body Mass Index.

Source: from the authors

Most were female (62%), while men represented 38%. Regarding body mass index (BMI), it was observed that only 8% of the participants had adequate values, while 92% had inadequate BMI. Regarding lifestyle, 68% were sedentary and 32% reported practicing some type of physical activity. Regarding smoking, 40% of the individuals were smokers and 60% did not smoke. With regard to the consumption of alcoholic beverages, 32% of the participants reported being alcoholics and 68% denied this habit.

In line with the factors mentioned above, it is important to highlight the importance of nutritional therapy in the life of patients with DM2, as an adequate diet goes beyond aesthetic and weight loss factors, because, in addition to directly impacting the BMI of patients, it can cause an improvement in glycemic parameters. In addition, as described by the Brazilian Diabetes Society in its guidelines, obesity is one of the main factors for the development of DM2, and that for each kg lost in people with obesity, the risk of developing DM2 is reduced by 16% (RAMOS *et al.*, 2023).

Regarding the recurrent risks of smoking, there is a high incidence worldwide, with more than 7 million deaths annually associated with this addiction, the use of smoking is the one with the greatest association with the contraction of Chronic Non-Communicable Diseases (NCDs), with prospects for an increase in the coming years. Alcohol, in turn, is consumed by 2.3 billion people worldwide, which, in excess, can cause the development of NCDs, with alcoholic hepatitis causing 27% of deaths from liver causes worldwide (FERNANDES; TEIXEIRA; KOCK, 2023).

Physical Activity consists of any muscle movement with energy expenditure, with physical activity structured according to the patient's needs and expected results, patients with impaired glucose tolerance undergoing aerobic physical activities had a 58% reduction in the incidence of the condition, a number higher than in patients using metformin, to which there was a reduction of 31% (SOUZA *et al.*, 2022). In disagreement with the results of the present study, in which sedentary lifestyle was high in most diabetic patients.

Systemic arterial hypertension was present in 82% of those evaluated, while 18% did not have this condition. Dyslipidemia was identified in 46% of the individuals, being absent in 54%. Regarding obesity, 26% of the participants were classified as obese and 74% as non-obese. Regarding drug treatment, 54% used drugs belonging to one therapeutic class, 28% used two classes and 18% used three classes of drugs.

The high rate of SAH is in line with the trend observed in recent epidemiological research, which describes the constancy and impact of chronic non-communicable diseases on adult health. It is reported that SAH often coexists with other metabolic problems, such as dyslipidemia and obesity, which causes a multimorbidity that demonstrates a greater

occurrence worldwide with premises of integrated health care approaches (MILLS *et al.*, 2020). It has also been described that excess adiposity and dyslipidemia are interconnected pathophysiological factors that potentiate the risk of cardiovascular events and usually lead to increased blood pressure and insulin resistance, with emphasis on the relevance of these comorbidities in the contemporary adult population (KLIGMAN *et al.*, 2019).

Hypertensive patients increasingly have conditions such as diabetes, dyslipidemia, and obesity, which in turn complicate clinical management, thus the need for polypharmacy is evident, since multiple therapeutic classes are necessary to control blood pressure and associated risk factors (CAREY *et al.*, 2020). This trend of concomitant use of multiple classes of medications is often related to the increase in comorbidities with a high probability of polypharmacy, especially in older adults or those with NCDs (EDMONDS *et al.*, 2020).

Considering the history of complications, of the 44 participants who responded to this step, 11.36% reported previous episodes of ulcerations and 6.82% had a history of amputations, and most (81.82%) did not have such a history. Finally, 24% of the individuals reported the presence of other comorbidities or associated conditions, while 76% did not report this type of occurrence.

The clinical evaluation of the feet of individuals with DM2 includes anatomical aspects, skin conditions, nail integrity, temperature, color, presence of calluses and lesions, in addition to the application of screening instruments for neuropathy and vascular evaluation. Tests of tactile sensitivity with monofilament, vibratory sensitivity with tuning fork, verification of the Aquilean tendon reflex, palpation of peripheral pulses and measurement of the ankle-brachial index (ABI) were included, these data proved to be fundamental for the early screening of neuropathic and vascular alterations, which represent important risk factors for foot complications.

It is essential to classify DPRDM after clinical evaluation, due to the possibility of stratification of the risk of ulceration, infection, and consequently amputation, as it guides conducts and periodicity of follow-up. The 2023 guidelines of the *International Working Group on the Diabetic Foot* (IWGDF) recommend, according to the patient's clinical findings, its classification; in general, the risk stratification considers: Low risk: absence of neuropathy and peripheral arterial disease (PAD); Moderate risk: neuropathy alone; High risk: neuropathy associated with deformities, PAD or history of ulceration or amputation (MONTEIRO-SOARES *et al.*, 2023).

In addition to risk classification, in the presence of lesions, it is recommended to use standardized systems such as the acronyms PEDIS, which stands for P (Perfusion), E (Extent), D (Depth), I (Infection) and S (Sensation), which classifies the risk between 1 and

4 (BUS *et al.*, 2020); or SINBAD, S (Site/location), I (Ischemia), N (Neuropathy) B (Bacterial infection) – presence of infection; A (Area) and D (Depth). The values of the SINBAD classification range from 0 to 6, with the higher the number, the greater the risk (JEFFCOATE *et al.*, 2018).

Table 2 shows the results of the clinical evaluation of the feet of individuals with Diabetes Mellitus, including anatomical aspects, skin conditions, nail integrity, temperature, color, presence of calluses and lesions, in addition to the application of screening instruments for neuropathy and vascular evaluation. Tests of tactile sensitivity with monofilament, vibratory sensitivity with tuning fork, verification of the tendon Achilles reflex, palpation of peripheral pulses, and measurement of the ankle-brachial index (ABI) were included. These data are essential for the early screening of neuropathic and vascular alterations, which represent important risk factors for foot complications.

Table 2

Evaluation of the feet and application of instruments in patients with DM2

FOOT ANATOMY	Frequency	Percentage
Normal	37	74
Loss of the plantar arch	3	6
Bunions	10	20
N=	50	
SKIN HYDRATION		
Normal	15	30,61
Skin dryness	25	51,02
Cracks	9	18,37
N=	49	
*=	1	
SKIN APPEARANCE		
Normal	41	83,67
Blackened	2	4,08
Bluish	3	6,12
Pale	3	6,12
N=	49	
*=	1	
TEMPERATURE		
Normal	42	84
Cold	8	16
N=	50	
NAIL AND SKIN INTEGRITY		
Normal	14	17,95
Interdigital lesions	17	21,79
Ringworm on nails	26	33,33
Improper nail trimming	10	12,82
Calluses	11	14
N=	50	
1st MONOFILAMENT APPLICATION		
Present sensitivity	37	83,67
Missing sensitivity	13	26
N=	50	
2nd SINGLE-END APPLICATION		

Present sensitivity	31	62
Missing sensitivity	19	38
N=	50	
3rd MONOFILAMENT APPLICATION		
Present sensitivity	34	68
Missing sensitivity	16	32
N=	50	
TUNING FORK TEST		
Vibratory sensitivity present	23	46
Missing vibratory sensitivity	23	46
Decreased vibratory sensitivity	4	8
N=	50	
TENDINOSUS REFLEX AQUILEUS		
Gift	45	90
Absent	5	10
N=	50	
PULSE PATION		
Gift	38	77,55
Absent	9	18,37
Decreased	2	4,08
N=	49	
*=	1	
ITB (PAST/PASB)		
<0.90	6	12
1,00-1,40	41	82
>1.40	3	6
N=	50	

ABI: Ankle Brachial Index
Source: from the authors

The evaluation of the feet in terms of anatomy revealed that 74% had feet with normal anatomy, while 6% had loss of the plantar arch and 20% had bunions. Regarding skin hydration, among the 49 evaluated, 30.61% had skin with normal hydration, 51.02% had dryness and 18.37% had cracks. Regarding skin color, 83.67% had normal color, while 4.08% had darkened skin, 6.12% bluish, and 6.12% pale.

Foot temperature was considered normal in 84% of the participants, being classified as cold in 16% of the cases. Regarding nail and skin integrity, it was found that 17.95% had normal conditions, while 21.79% had interdigital lesions, 33.33% nail mycosis, 12.82% inadequate nail cutting and 14.10% calluses.

The alterations, or deformities, of the feet of patients with DM are a finding of great importance in a study carried out in Minas Gerais by Souza *et al.*, (2023); it also showed a predominance in feet without alterations (54.7%), the most common deformity found in the study were the hammertoes (31.4%), followed by Charccot's arthropathy (8.1%) and claw toes (5.8%). In consonance, the presence of isolated calluses was present in (65.1%), the others had an association of fissures, a predominance of color without alteration (50%), most with dry/scaly skin (51.2%). Another important point was the presence of 53.5% of the

sample presenting inadequate nail cuts alone and 32.6% with Onychomycosis (Souza *et al.*, 2023)

In the evaluation of tactile sensitivity with monofilament, in the first application, 83.67% of the participants had preserved sensitivity, while 26% showed no sensitivity. In the second application, 62% maintained the present sensitivity and 38% were absent. In the third application, 68% maintained sensitivity and 32% continued without sensory response to the stimulus.

The application of the 10 g monofilament to evaluate the protective tactile sensitivity is the main screening instrument for DN, due to its low cost, ease of application, and good accuracy. The monofilament test is performed in order to evaluate tactile sensitivity, where the monofilament must be pressed perpendicular to the skin three times, in order to increase the reliability of the test and avoid interference in certain skin regions until the patient's feedback with the impression that the touch of the monofilament was felt (BUS *et al.*, 2020).

In the tuning fork vibration sensitivity test, 46% of the individuals had preserved vibratory sensitivity, while another 46% had no vibratory sensitivity and 8% had decreased vibratory sensitivity. In the evaluation of the tendon Achilles reflex, 90% of the participants had a reflex present and 10% absent.

On the other hand, the complementary analysis with a tuning fork of 128 Hz, to evaluate the vibratory sensitivity, where the tuning fork must be vibrated and applied on a bony prominence and evaluate the patient's sensitivity, this test evaluates the functionality of large-caliber nerve fibers. A tuning fork or reflex hammer is also used to verify the Tendineum-Aquilean reflex, performed with the patient sitting with a light percussion in search of plantar flexion to evaluate the integrity of the peripheral reflex arch. These tests become essential for detecting sensorineural impairment. The loss of protective sensitivity is directly associated with an increased risk of ulceration, since the patient no longer perceives repetitive microtraumas (BUS *et al.*, 2020).

Palpation of pulses revealed the presence of peripheral pulses in 77.55% of the 49 evaluated, absence in 18.37% and decreased pulses in 4.08%. Finally, the measurement of the ankle-brachial index (ABI) showed that 12% had values below 0.90, indicative of possible peripheral arterial disease, while 82% had normal ABI (between 1.00 and 1.40) and 6% had values above 1.40.

ABI is a non-invasive test listed for the diagnosis of Peripheral Arterial Disease, widely recommended by national and international guidelines. The procedure consists of the ratio, that is, division between the systolic blood pressure of the posterior tibial or pedal artery, located near the ankle, and the brachial systolic pressure, using a sphygmomanometer and

portable Doppler for greater accuracy. The internationally disseminated cut-off values refer to: ABI < 0.90, indicative of DBH; 0.91–0.99, borderline; 1.00–1.40, normal; and > 1.40, suggestive of calcification or vascular stiffness, is a condition frequently observed in people with T2DM (BUS *et al.*, 2020; ABOYANS *et al.*, 2018).

The alteration in the ABI exam is associated with a worse prognosis, with a higher risk of delayed healing, infection, and amputation, as highlighted in the recommendations of the International Working Group on the Diabetic Foot (2020). In addition, the prevalence of PAD detected by ABI in people with diabetes varies approximately between 10% and 30%, even if even asymptomatic individuals are included, it is up to health professionals to have an effective systematic screening process (BUS *et al.*, 2020; ABOYANS *et al.*, 2018).

Inferential analysis was conducted to evaluate the associations between clinical and lifestyle characteristics of participants with T2DM and ankle-brachial index (ABI) values. Statistical tests were used to verify significant differences between groups based on variables such as peripheral pulses, temperature, foot sensitivity, Achilles tendon reflex, obesity, and level of physical activity, in order to identify risk factors related to vascular health and foot complications.

Table 3

Comparison of Brachial Ankle Index with pulse palpation, temperature, first and second monofilament application, Achilles tendon reflex, tuning fork, blood glucose, sedentary lifestyle, skin color, and obesity

ITB VS PULSE PALPATION	N	Median	P-value
Gift	38	2	Pairwise Method 0.001
Absent	9	1	
Decreased	2	2	
Gift	49		
ITB X TEMPERATURE			
Normal	42	2	Mann-Whitney 0.001
Cold	8	1,5	
ITB X 1ST MONOFILAMENT APPL			
Gift	37	2	Mann-Whitney 0.001
Absent	13	2	
ITB X 2ND MONOFILAMENT APPLICATION			
Gift	31	2	Mann-Whitney 0.004
Absent	19	2	
ITB X ACHILLES TENDON REFLEX			
Gift	45	2	Mann-Whitney 0.001
Absent	5	1	
ITB X TUNING FORK TEST			
Vibratory sensitivity present	23	2	Pairwise Method 0.001
Missing vibratory sensitivity	23	2	
Decreased vibratory sensitivity	4	2,5	

Global	50		
ITB X SEDENTARY LIFESTYLE			
Yes	34	2	Mann-Whitney 0.015
No	16	2	
ITB X COLOR OF THE SKIN or Hydration			
Normal	15	2	Kruskal-Wallis 0.080
Skin dryness	25	2	
Cracks	9	2	
ITB VS OBESITY			
YES	13	2	Mann-Whitney 0.021
NO	37	2	

ABI: Ankle Brachial Index / APL: Application
Source: from the authors

It was found that participants with decreased pulse palpation had lower ankle-brachial index (ABI) values compared to those with preserved pulses ($p=0.001$). Similarly, individuals with normal foot temperature exhibited higher ABI values than those with cold extremities ($p=0.001$). The presence of tactile sensitivity at the first application of the monofilament was associated with higher ABI values in relation to cases of absence of sensitivity ($p=0.001$). A similar result was observed in the second application of the monofilament, in which the preserved sensitivity was related to a higher ABI ($p=0.004$).

In addition, the preservation of the Achilles tendon reflex was related to better ABI indices when compared to its absence ($p=0.001$). In the tuning fork vibratory sensitivity test, ABI values differed between the groups, with the main difference observed between those with decreased sensitivity and those with total absence of vibratory sensitivity ($p=0.001$).

It was also observed that sedentary participants had higher ABI values compared to non-sedentary participants ($p=0.015$). On the other hand, no statistically significant differences were found in ABI values when considering the different groups of skin color ($p=0.08$). Finally, individuals classified as obese had higher ABI values compared to non-obese individuals ($p=0.021$).

The observation of the association between decreased peripheral pulses and lower ABI values is described by the *European Society of Cardiology* (ESC) and the *American Heart Association* (AHA), establishing $ABI < 0.90$ as a diagnostic criterion for PAD and emphasizing that the reduction or absence of peripheral pulses is one of the main clinical findings linked to this reduction, in addition to associating hypothermia with periphery and being described as a classic sign of peripheral hypoperfusion (GERHARD-HERMAN *et al.*, 2017; ABOYANS *et al.*, 2018).

The relationship between peripheral neuropathy and ABI reduction is described in the IWGDF guidelines, where the coexistence of DN and PAD is indicated, as there is a sharing of pathophysiological mechanisms such as endothelial dysfunction, chronic inflammation,

and atherosclerosis (BUS *et al.*, 2020). The American Diabetes Association (ADA) describes that the loss of protective sensitivity is associated with a higher risk of ulceration, notably when combined with arterial insufficiency (AMERICAN DIABETES ASSOCIATION, 2024). The association between obesity and increased ABI values is mainly due to medial arterial calcification, which is very common in individuals with DM and/or metabolic syndrome, which due to arterial stiffness can cause $>1,40$ results, also interfering in the visualization of these in sedentary individuals (GERHARD-HERMAN *et al.*, 2017; ABOYANS *et al.*, 2018).

The importance of the present study lies in the early evaluation of patients with DM2. In addition, the work is configured as a reference for the analysis of the conditions identified and the problems existing in the service according to the needs of the patients, contributing to the strengthening of comprehensive patient care and to the optimization of self-care practices. As future perspectives, the possibility of carrying out evaluations in different services, with larger samples and inclusion of other types of Diabetes Mellitus, is highlighted.

4 FINAL CONSIDERATIONS

Most participants were female. The main associated risk factors identified are related to high and inadequate BMI, and almost all of them have this condition. In addition, more than half of the patients are sedentary. Among the prevalent chronic diseases, in addition to diabetes, arterial hypertension and dyslipidemia stand out, which affect approximately half of those evaluated. It is also observed that a minority already has a history of previous ulcerations and amputations. In the clinical evaluation, the feet present skin dryness, loss of tactile sensitivity and absent vibratory sensitivity. In some, altered ABI indicates Peripheral Arterial Disease and is associated with physical examination findings such as decreased pulses, cold extremities and loss of sensitivity; in others, higher ABI values are found in obese and sedentary individuals. The educational leaflet with guidance on the identified risks was presented to the participants and reinforces the need to reflect on changes in habits to prevent future complications in the feet.

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