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Biometric Skin parameters in Individuals with Diabetes Mellitus: moisture, oiliness, elasticity, and pH**

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ABSTRACT

Objective: To assess, through skin biometry, skin moisture, elasticity, oiliness, and pH in individuals with type 1 and type 2 diabetes mellitus. The evaluated regions included the forearm, palm and dorsum of the hands, leg, heel, and dorsum and plantar surface of the feet. The examination was performed before and after the use of a 10% urea-based cream. **Method:** This was an exploratory, longitudinal clinical study with a before-and-after design and no control group, conducted in primary healthcare units in the city of Pouso Alegre, Minas Gerais, Brazil. Thirty-four individuals participated in the study. Measurements were performed on days 0, 5, and 10 using the Digital Skin Analyser and a pH meter, model 6118 (Fujian WatapproveElectronic), following the application of a 10% urea cream. **Results:** The evaluated regions exhibited significant changes on different days of assessment. A marked improvement in skin elasticity and in the overall balance of cutaneous parameters was observed following the use of the cream. **Conclusion:** After 10 days of use of the 10% urea cream, skin biometry indicated improvements in moisture, oiliness, elasticity, and pH across the evaluated areas, demonstrating greater skin balance compared with the first day of assessment and supporting the applicability of the product as a simple and beneficial skincare measure.

KEYWORDS: Skin. Diabetes mellitus. Biometric analysis. Stomatherapy. Self-care.

Parâmetros biométricos da pele em pessoas com diabetes *mellitus*: umidade, oleosidade, elasticidade e pH

RESUMO

Objetivo: Avaliar, por biometria cutânea, a umidade, elasticidade, oleosidade e pH da pele de pessoas com diabetes *mellitus* tipos 1 e 2. A regiões avaliadas foram: antebraço, palma e dorso das mãos, perna, calcâneo e dorso e planta dos pés. O exame foi realizado antes e depois do uso de creme à base de ureia a 10%. **Método:** Estudo clínico exploratório, longitudinal, do tipo antes e depois, sem grupo controle, realizado em unidades básicas de saúde de Pouso Alegre (MG). Participaram 34 indivíduos. As medidas ocorreram nos dias 0, 5 e 10, utilizando o *Skin Analyser Digital* e o medidor de pH modelo 6118 (*Fujian WatapproveElectronic*), após aplicação de creme de ureia a 10%. **Resultados:** As regiões avaliadas apresentaram alterações significativas em dias distintos. Observou-se melhora expressiva na elasticidade e no equilíbrio geral dos parâmetros

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cutâneos após o uso do creme. **Conclusão:** Após 10 dias de uso do creme de ureia a 10%, a biometria cutânea indicou melhora na umidade, oleosidade, elasticidade e pH das áreas avaliadas, evidenciando maior equilíbrio da pele em comparação com o primeiro dia de avaliação, demonstrando a aplicabilidade do produto como cuidado simples e benéfico.

PALAVRAS-CHAVE: Pele. Diabetes *mellitus*. Análise biométrica. Estomaterapia. Autocuidado.

Parámetros biométricos de lapiel en personas con Diabetes Mellitus: humedad, oleosidad, elasticidad y pH

RESUMEN

Objetivo: Evaluar, mediante biometría cutánea, la humedad, elasticidad, oleosidad y pH de la piel de personas con diabetes mellitus tipos 1 y 2. Las regiones evaluadas fueron: antebrazo, palma y dorso de las manos, pierna, calcáneo y dorso y planta de los pies. El examen se realizó antes y después del uso de crema a base de urea al 10%. **Método:** Estudio clínico exploratorio, longitudinal, de tipo antes y después, sin grupo control, realizado en unidades básicas de salud de Pouso Alegre (MG). Participaron 34 individuos. Las mediciones se realizaron en los días 0, 5 y 10, utilizando el Skin Analyser Digital y el medidor de pH modelo 6118 (Fujian WatapproveElectronic), tras la aplicación de crema de urea al 10%. **Resultados:** Las regiones evaluadas presentaron alteraciones significativas en distintos días. Se observó una mejora significativa en la elasticidad y en el equilibrio general de los parámetros cutáneos tras el uso de la crema. **Conclusión:** Después de 10 días de uso de la crema de urea al 10%, la biometría cutánea indicó una mejora en la humedad, oleosidad, elasticidad y pH de las áreas evaluadas, evidenciando un mayor equilibrio de la piel en comparación con el primer día de evaluación, lo que demuestra la aplicabilidad del producto como un cuidado simple y beneficioso.

PALABRAS CLAVE: Piel. Diabetes mellitus. Análisis biométrico. Estomaterapia. Autocuidado.

INTRODUCTION

Diabetes *mellitus* (DM) is the generic term assigned to a group of diseases affecting insulin production, resulting in glycemic disturbances. Type 1 diabetes is the most common form and results from the destruction of pancreatic β-cells, leading to insulin deficiency and complete insulin dependence, thereby requiring the use of exogenous insulin. In contrast, type 2 diabetes is characterized by impaired insulin secretion, insulin resistance, or alterations in glucose uptake. Commonly associated with obesity and other comorbidities, type 2 diabetes accounts for approximately 90% of DM cases. Initial treatment often involves oral medications, while insulin is used when necessary solely for glycemic control. There are also rare forms of diabetes, such as gestational, type 5, and drug-induced diabetes. [1–3] DM is estimated to affect 783 million people by 2045.

Diagnosis, which frequently includes glycated hemoglobin (HbA1c) testing, increases susceptibility to other diseases and aesthetically impacts an individual's life, being intrinsically linked to self-esteem[4-7].

If not adequately controlled, DM may trigger several complications, including diabetes-related retinopathy, nephropathy, peripheral neuropathy (PN), as well as skin lesions with impaired healing that may progress to severe infections and, in extreme cases, limb amputations. Data from the World Health Organization indicate that individuals with diabetes are up to 20 times more likely to undergo amputation compared with individuals without a diagnosis of DM.[5,6]

Diabetes-related foot disease (DFD) plays a particularly prominent role, given its high incidence and direct impact on patients' lives, constituting a cutaneous condition that predisposes individuals to amputations and often irreversible complications. It is associated with approximately 80% of amputations worldwide. [8]

Skin biometry is a branch of bioengineering dedicated to the study of the biological, mechanical, and functional characteristics of the skin through precise and noninvasive measurements. It employs specialized instruments to quantify

physicochemical properties such as moisture, oiliness, elasticity, pH, transepidermal water loss, and pigmentation, enabling an objective and rigorous assessment of skin physiology[9].

Epidermal barrier function is regulated by endogenous and exogenous factors, with DM playing a prominent role, as studies have shown that the diabetic condition promotes loss of skin moisture and that patients with adequate glycemic parameters present better moisture indices. Cutaneous xerosis, also known as skin dryness, is found in nearly half of patients with DM over 60 years of age, a condition that predisposes to damage of the stratum corneum. Approximately 90% of individuals with diabetes report chronic pruritus, which, through scratching, may result in local trauma. [10]

In addition to these factors, the assessment of skin pH is essential for evaluating skin health. The physiological pH of the epidermis may vary according to anatomical location, moisture, and ethnic factors. Lower pH values have been observed in individuals with Black skin compared with those with White skin. The physiological pH of the forearm in a healthy adult man ranges from 5.4 to 5.9. pH plays a crucial role in maintaining the skin barrier, and preserving it within a healthy range helps prevent conditions such as dermatitis and psoriasis. However, the literature describes that glycemic alterations associated with DM increase this parameter. [10,11]

An increase in epidermal pH, associated with other stress-related factors, results in decreased vascular endothelial growth factor (VEGF) levels and reduced production of skin lipids, consequently lowering skin oiliness. The glycation process, in turn, is responsible for the accumulation of advanced glycation end-products (AGEs), which reorganize keratinocytes, thin the skin, and deform collagen fibers, rendering them more rigid and reducing their elastic potential. [12]

The Digital Skin Analyser (DSA) device enables the assessment of skin moisture, elasticity, and oiliness, [13] using bioelectrical impedance analysis technology, in which reference values vary according to the anatomical region evaluated. Moisture normally ranges from 40% to 60%, and oiliness from 23% to 33% in facial parameters, whereas in the palmar region and arms, healthy moisture ranges from 40% to 65% and oiliness from 16% to 22%, varying according to the region under investigation. The equipment automatically provides an indication of whether elasticity levels fall within the range considered healthy. [13]

This study addresses the process of objective measurement of physicochemical and functional skin parameters obtained through instrumental methods, including pH, oiliness, moisture, and elasticity. These indicators make it possible to analyze skin barrier integrity, hydrolipidic balance, and the skin's ability to maintain homeostasis, which are fundamental factors in clinical studies and health research.

Given the wide range of studies on skin alterations observed in patients with diabetes, the following question arises: what are the biometric parameters of skin moisture, elasticity, oiliness, and pH in individuals with DM and preserved skin integrity? The hypothesis is that biometric assessment, through variations in skin moisture, elasticity, and oiliness, may contribute to the screening of lesions and other cutaneous complications.

OBJECTIVES

To assess skin moisture, elasticity, oiliness, and pH on the forearm, palm and dorsum of the hands, leg, heel, and dorsum and plantar surface of the feet in individuals with type 1 and type 2 diabetes mellitus, before and after the use of a 10% urea-based cream, through skin biometry.

METHODS

This was an exploratory, longitudinal clinical study with a before-and-after design, without a control group, assessing the association between improvements in skin parameters and product use. The study was submitted to the Research Ethics Committee (REC) of the University of Vale do Sapucaí (Univás), Pouso Alegre, Minas Gerais, Brazil, and approved under Certificate of Presentation for Ethical Consideration (CAAE) No. 59298622.0.0000.5102 and substantiated opinion no. 5,524,892. The regulations established by the National Health Council (CNS Resolution No. 466/2012) of the Brazilian

Ministry of Health, which govern research involving human participants, were rigorously followed. Through the Informed Consent Form (ICF), participants were informed about the objectives of the study, as well as the guarantee of anonymity and their right to withdraw at any time.

Data were collected in primary healthcare units linked to the Family Health Strategy (FHS) in the municipality of Pouso Alegre, Minas Gerais, Brazil. The sample was selected by convenience sampling, and 43 participants diagnosed with type 1 or type 2 DM were invited to participate. Eligibility criteria included the following: inclusion criteria, patients with type 1 or type 2 diabetes, of either sex, aged ≥18 years; exclusion criteria, patients with reported or confirmed sensitivity to the compounds of the 10% urea cream and those who declined to participate in the study.

The calibrated instruments used included the Digital Skin Analyser (DSA), manufactured by SkinUp, which reports 98% accuracy in assessing skin moisture, oiliness, and elasticity through bioelectrical impedance analysis, and the skin pH meter, model 6118, manufactured by Fujian WatapproveElectronic Technology, used in conjunction to evaluate skin pH. The pH meter operates תועצמאב a flat-tip electrode that enables readings through direct contact with the skin, with values ranging from 0.0 (acidic) to 14.0 (alkaline).

A compounded 10% urea cream prepared by the compounding pharmacy Phitofarma (Crt Farmácia de Manipulação Ltda.) was also used, with the following composition: 10% urea and vehicle q.s. to volume (q.s.p.); neutral glycerin liquid soap was used for antisepsis of the areas to be evaluated. These products were provided to patients individually and in subdivided quantities. Participants were instructed to apply the 10% urea cream at night, before bedtime, following local cleansing with neutral glycerin liquid soap.

For skin analyses, the most exposed anatomical regions, where alterations are typically observed more frequently, were selected:

- Dorsum and palm (center) of the hands, and forearm;
- Dorsum and plantar surface (center) of the feet, heel, and leg.

Measurements in the three assessment sessions were performed 20 minutes after local cleansing and application of the 10% urea cream, using the DSA and the skin pH meter, model 6118. The devices and products were purchased by the authors, and no conflicts of interest were identified in the present study.

A sociodemographic questionnaire and an assessment form to record participant progress were administered at the beginning of the study, and the data were entered into Microsoft Excel 365 for tabulation and statistical analysis.

The study was conducted in sequential stages:

First stage: identification of primary healthcare units in the municipality with the highest number of patients with DM, including the Municipal Diabetes Education Center (CEMED), to select potential participants according to the established eligibility criteria. During this phase, nursing professionals responsible for the units were also contacted to provide information regarding the methodology and scheduling for the initiation of the study.

Second stage: visits to eligible units to identify potential participants; patients were approached either during home visits or at the healthcare unit, where detailed information about the study was provided and the Informed Consent Form (ICF) was signed. During the same phase, the sociodemographic questionnaire was administered, and baseline assessments were conducted on day zero (D0) or day one (D1), according to the proposed methodology.

Third stage: sequential assessments conducted on day five (D5) and day ten (D10).

Fourth stage: data tabulation in Microsoft Excel 365 and statistical analysis using the Statistical Package for the Social Sciences (SPSS), version 26.0.

Data were presented as mean ± standard deviation for continuous quantitative variables, regardless of whether they exhibited a normal or non-normal distribution. Paired Student's t-test and the Wilcoxon signed-rank test were used to compare means at each observed time point and, similarly, the medians of non-normally distributed variables. McNemar's test was used to compare the frequencies of categorical and discretized variables across the assessment time points.

A significance level of 5% ($p < 0.05$) was adopted as the criterion for acceptance or rejection in the statistical tests.

Fifth stage: preparation of the discussion, conclusion, and manuscript writing.

RESULTS

Initially, 43 participants were assessed according to the eligibility criteria; however, nine did not return for the sequential assessments, resulting in a final sample of 34 patients.

Descriptive analyses of measures of central tendency (mean and median) for age, time since diagnosis, and standard deviation of family income are presented in Table 1.

Table 2 presents the absolute and relative frequencies of discrete participant variables, including sex, marital status, occupation, religion, presence of wounds, type of diabetes mellitus (DM), area of residence (rural or urban), availability of electricity in the household, sanitation, and access to piped water supply.

Table 3 presents the biometric parameters of the plantar surface, dorsum of the foot, heel, and leg, on both the right and left sides, throughout the period from day 1 to day 10, in relation to the use of the 10% urea cream, comparing the values with the skin condition prior to product application, referred to in the study as the baseline parameter.

Table 1. Age, years since diabetes diagnosis, and family income of participants with diabetes

Variables	Mean	Standard Deviation	Median
Age	64.32	8.49	64.5
Years since diagnosis	9.76	9.59	5.5
Family income	2,944*	3,332*	2,000*

*R$ 2,944.00, R$ 3,332.00, R$ 2,000.00
Source: The authors.

Table 2. Description of Sociodemographic and Clinical Variables of Participants with Diabetes *Mellitus*.

Variables	**n**	**%**
Gender		
Female	29	85.29
Male	5	14.71
Marital status		
Without a partner	19	55.87
With a partner	15	44.12
Occupation		
Retired/pensioner	13	38.24
Homemaker	11	32.35
Public employee/self-employed/ CLT	10	29.41
Religion		
Catholic	21	61.76
Evangelical	10	29.41
Jehovah's Witness	2	5.88
Umbanda	1	2.94
Housing conditions		
Urban area/sanitation/piped water/electricity	34	100.00
Previous wound history		
Yes	5	14.71
No	29	85.29
Type of DM		
1	1	2.94
2	33	97.06

CLT: Consolidation of Labor Laws; DM: diabetes ***mellitus***.
Source: The authors.

Table 3. Skin Parameters in the Central Regions of the Plantar Surface, Dorsum of the Foot, Heel, and Leg.

	Variables	Time (days)	Baseline (before use, D0) Mean±SD	Post-use: Mean±SD	Test	*p*-value
Right dorsum of the foot	pH	1	6,50±0,32	6.59±0.33	*t* pareado	0.074
	pH	5	6.50±0.32	6.58±0.26	*t* pareado	0.171
	pH	10	6.50±0.32	6.62±0.24	*t* pareado	0.037*
	Umidade	1	25.94±8.74	28.09±11.33	Wilcoxon	0.330
	Umidade	5	25.94±8.74	30.76±12.28	Wilcoxon	0.013*
	Umidade	10	25.94±8.74	29.11±11.63	Wilcoxon	0.460
	Oleosidade	1	37.00±11.14	33.27±12.08	Wilcoxon	0.042*
	Oleosidade	5	37.00±11.14	34.68±11.51	Wilcoxon	0.367
	Oleosidade	10	37.00±11.14	29.11±11.94	Wilcoxon	0.018*
	Elasticity	1	1.03±0.17	1.21±0.41	McNemar	0.031*
	Elasticity	5	1.03±0.17	1.32±0.47	McNemar	0.013*
	Elasticity	10	1.03±0.17	1.26±0.45	McNemar	0.010*
Left dorsum of the foot	pH	1	6.48±0.29	6.55±0.34	*t* pareado	0.198
	pH	5	6.48±0.29	6.54±0.25	*t* pareado	0.281
	pH	10	6.48±0.29	6.59±0.24	*t* pareado	0.054
	Moisture	1	25.07±7.39	26.18±9.54	Wilcoxon	0.317
	Moisture	5	25.07±7.39	35.36±8.68	Wilcoxon	0.013*
	Moisture	10	25.07±7.39	27.19±10.46	Wilcoxon	0.460
	Oiliness	1	37.49±11.06	41.77±30.97	Wilcoxon	0.376
	Oiliness	5	37.49±11.06	35.36±12.17	Wilcoxon	0.173
	Oiliness	10	37.49±11.06	36.50±10.85	Wilcoxon	0.556
	Elasticity	1	1.00±0.00	1.21±0.41	McNemar	0.031*
	Elasticity	5	1.00±0.00	1.09±0.29	McNemar	0.013*
	Elasticity	10	1.00±0.00	1.14±0.43	McNemar	0.010*
Right plantar surface of the foot	pH	1	6.57±0.34	6.53±0.32	*t* pareado	0.437
	pH	5	6.57±0.34	6.50±0.42	*t* pareado	0.362
	pH	10	6.57±0.34	6.56±0.31	*t* pareado	0.815
	Moisture	1	25.59±6.68	25.12±8.13	Wilcoxon	0.018*
	Moisture	5	25.59±6.68	27.47±9.98	Wilcoxon	0.811
	Moisture	10	25.59±6.68	25.91±6.76	Wilcoxon	0.123
	Oiliness	1	38.87±10.12	36.73±11.90	Wilcoxon	0.001*
	Oiliness	5	38.87±10.12	36.05±11.91	Wilcoxon	0.021*
	Oiliness	10	38.87±10.12	37.99±9.97	Wilcoxon	0.026*
	Elasticity	1	1.03±0.17	1.06±0.24	McNemar	0.375
	Elasticity	5	1.03±0.17	1.15±0.36	McNemar	0.094
	Elasticity	10	1.03±0.17	1.06±0.24	McNemar	0.375
Left plantar surface of the foot	pH	1	6.61±0.33	6.58±0.44	*t* pareado	0.524
	pH	5	6.61±0.33	6.52±0.33	*t* pareado	0.062
	pH	10	6.61±0.33	6.55±0.35	*t* pareado	0.405
	Moisture	1	27.01±8.90	24.76±7.59	Wilcoxon	0.000*
	Moisture	5	27.01±8.90	26.92±10.11	Wilcoxon	0.030*
	Moisture	10	27.01±8.90	25.76±10.66	Wilcoxon	0.061
	Oiliness	1	37.74±11.03	37.05±11.35	Wilcoxon	0.000*
	Oiliness	5	37.74±11.03	36.51±11.55	Wilcoxon	0.023
	Oiliness	10	37.74±11.03	37.73±10.66	Wilcoxon	0.075
	Elasticity	1	1.08±0.29	1.00±0.00	McNemar	0.375
	Elasticity	5	1.08±0.29	1.06±0.24	McNemar	0.312
	Elasticity	10	1.08±0.29	1.06±0.24	McNemar	0.312

It continues...

Table 3. Continuation.

	Variables	Time (days)	Baseline (before use, D0) Mean±SD	Post-use: Mean±SD	Test	*p*-value
Right heel	pH	1	6.60±0.32	6.58±0.44	*t* pareado	0.397
	pH	5	6.60±0.32	6.55±0.39	*t* pareado	0.688
	pH	10	6.60±0.32	6.52±0.35	*t* pareado	0.054
	Moisture	1	24.98±7.95	25.44±8.40	Wilcoxon	0.090
	Moisture	5	24.98±7.95	26.82±9.89	Wilcoxon	0.884
	Moisture	10	24.98±7.95	25.05±7.72	Wilcoxon	0.480
	Oiliness	1	37.92±10.49	37.08±11.80	Wilcoxon	0.098
	Oiliness	5	37.92±10.49	36.68±11.93	Wilcoxon	0.784
	Oiliness	10	37.92±10.49	37.47±10.77	Wilcoxon	0.167
	Elasticity	1	1.06±0.24	1.06±0.24	McNemar	0.375
	Elasticity	5	1.06±0.24	1.09±0.29	McNemar	0.312
	Elasticity	10	1.06±0.24	1.06±0.24	McNemar	0.375
Left heel	pH	1	6.59±0.38	6.53±0.43	*t* pareado	0.104
	pH	5	6.59±0.38	6.56±0.34	*t* pareado	0.798
	pH	10	6.59±0.38	6.54±0.28	*t* pareado	0.188
	Moisture	1	26.28±6.63	25.39±8.04	Wilcoxon	0.006*
	Moisture	5	26.28±6.63	27.33±10.64	Wilcoxon	0.120
	Moisture	10	26.28±6.63	25.46±7.09	Wilcoxon	0.287
	Oiliness	1	39.39±9.94	37.03±11.40	Wilcoxon	0.006*
	Oiliness	5	39.39±9.94	36.08±11.91	Wilcoxon	0.001*
	Oiliness	10	39.39±9.94	38.10±10.61	Wilcoxon	0.167
	Elasticity	1	1.08±0.29	1.00±0.00	McNemar	0.375
	Elasticity	5	1.08±0.29	1.11±0.33	McNemar	0.234
	Elasticity	10	1.08±0.29	1.06±0.24	McNemar	0.500
Right leg	pH	1	6.57±0.29	6.58±0.43	*t* pareado	0.925
	pH	5	6.57±0.29	6.55±0.29	*t* pareado	0.761
	pH	10	6.57±0.29	6.55±0.30	*t* pareado	0.945
	Moisture	1	25.07±8.00	24.92±8.10	Wilcoxon	0.251
	Moisture	5	25.07±8.00	26.55±9.45	Wilcoxon	0.321
	Moisture	10	25.07±8.00	25.92±9.08	Wilcoxon	0.109
	Oiliness	1	37.60±12.00	36.45±11.93	Wilcoxon	0.062
	Oiliness	5	37.60±12.00	35.84±12.09	Wilcoxon	0.004*
	Oiliness	10	37.60±12.00	36.86±11.65	Wilcoxon	0.011
	Elasticity	1	1.06±0.24	1.03±0.17	McNemar	0.375
	Elasticity	5	1.06±0.24	1.08±0.28	McNemar	0.312
	Elasticity	10	1.06±0.24	1.02±0.17	McNemar	0.375
Left leg	pH	1	6.48±0.38	6.61±0.34	*t* pareado	0.276
	pH	5	6.48±0.38	6.52±0.30	*t* pareado	0.596
	pH	10	6.48±0.38	6.60±0.27	*t* pareado	0.816
	Moisture	1	25.03±7.79	25.20±8.12	Wilcoxon	0.367
	Moisture	5	25.03±7.79	26.61±9.64	Wilcoxon	0.061
	Moisture	10	25.03±7.79	25.96±8.97	Wilcoxon	0.173
	Oiliness	1	37.69±11.55	36.97±11.59	Wilcoxon	0.169
	Oiliness	5	37.69±11.55	35.96±11.48	Wilcoxon	0.000*
	Oiliness	10	37.69±11.55	36.98±11.52	Wilcoxon	0.012*
	Elasticity	1	1.00±0.00	1.02±0.17	McNemar	0.375
	Elasticity	5	1.00±0.00	1.08±0.28	McNemar	0.312
	Elasticity	10	1.00±0.00	1.03±0.17	McNemar	0.375

D0: day zero; SD: Standard Deviation.
*p=0.05.
Source: The authors.

For the analysis of quantitative variables with a normal distribution, Student's t-test[14] was used to assess differences across the evaluated time points. A p-value < 0.05 was considered indicative of statistically significant differences over time. For the remaining quantitative variables, data normality was initially assessed. When normal distribution was observed, Student's t-test was applied; otherwise, the Wilcoxon signed-rank test[15] for paired samples was used.

For non-quantitative variables assuming predetermined values (e.g., 1, 2, or 3), McNemar's test[16] was used to assess differences between the evaluated time points. The elasticity variable, classified as multinomial (ordinal) due to its fixed values (1, 2, or 3), was treated differently in both descriptive statistics and time-point comparisons and was analyzed using McNemar's test.

pH

Statistical significance was observed for pH in the comparison between D0 without cream use and the final assessment at D10 in the DPD and DPE regions (p=0,037).

Moisture

Statistical significance was observed in moisture assessment in the right dorsum of the foot (RDF) when comparing D0 without cream use and D5 (p = 0.013); in the right plantar surface of the foot (RPF) between baseline D0 (without cream application) and D0 after application (p = 0.018); in the left plantar surface of the foot (LPF) between baseline D0 (without cream application) and D0 after application (p < 0.000); in the LPF between D0 and D5 (p = 0.030); and in the left heel between D0 before and after cream application (p=0,006).

Oiliness

Regarding oiliness, statistically significant differences were observed in the right dorsum of the foot (RDF) between baseline D0 and D10 (p = 0.018); in the right plantar surface of the foot (RPF) across all assessments, namely between baseline D0 and D0 after cream application (p < 0.001), D0 and D5 (p = 0.021), and D0 and D10 (p = 0.026); in the left plantar surface of the foot (LPF) between baseline D0 and D0 after cream application (p < 0.001); in the left heel (LH) between baseline D0 and D0 after cream application (p = 0.006) and between D0 and D5 (p < 0.001); in the right leg (RL) between D0 and D5 (p = 0.004); and in the left leg (LL) between D0 and D5 (p < 0.001) and between D0 and D10 (p=0,012).

Elasticity

Regarding elasticity, statistical significance was observed in the right dorsum of the foot (RDF) and left dorsum of the foot (LDF) between baseline D0 and D0 after cream application (p = 0.031), between D0 and D5 (p = 0.013), and between D0 and D10 (p = 0.010).

Table 4 presents the biometric parameters of the central dorsum and palm of the hands, as well as the forearm, on both the right and left sides. Student's t-test was applied for quantitative variables with normal distribution; otherwise, the Wilcoxon signed-rank test was used. A p-value > 0.05 indicated normality in one of the two tests. For non-quantitative variables, McNemar's test was used.

pH

Regarding pH, statistical significance was observed in the right forearm (RF) between baseline D0 and D5 (p=0,044).

Table 4. Skin Parameters in the Central Region of the Dorsum and Palm of the Hands and the Forearm.

	Variable	Time (days)	Baseline (before use, D0) Mean±SD	Post-use: Mean±SD	Test	*p*- value
Forearm Right Forearm	pH	1	6.60±0.32	6.59±0.33	*t* paired	0.872
	pH	5	6.60±0.32	6.51±0.32	*t* paired	0.044*
	pH	10	6.60±0.32	6.55±0.32	*t* paired	0.413
	Moisture	1	25.49±8.24	25.94±7.79	Wilcoxon	0.480
	Moisture	5	25.49±8.24	27.75±9.88	Wilcoxon	0.734
	Moisture	10	25.49±8.24	27.54±9.70	Wilcoxon	0.640
	Oiliness	1	37.39±12.13	36.86±10.67	Wilcoxon	0.748
	Oiliness	5	37.39±12.13	27.75±9.88	Wilcoxon	0.450
	Oiliness	10	37.39±12.13	35.44±11.15	Wilcoxon	0.027*
	Elasticity	1	1.05±0.23	1.05±0.23	McNemar	0.500
	Elasticity	5	1.05±0.23	1.11±0.32	McNemar	0.312
	Elasticity	10	1.05±0.23	1.11±0.32	McNemar	0.234
Left Forearm	pH	1	6.57±0.31	6.55±0.32	*t* paired	0.561
	pH	5	6.57±0.31	6.50±0.35	*t* paired	0.152
	pH	10	6.57±0.31	6.59±0.29	*t* paired	0.703
	Moisture	1	25.57±8.14	29.29±22.76	Wilcoxon	0.477
	Moisture	5	25.57±8.14	26.48±9.09	Wilcoxon	0.313
	Moisture	10	25.57±8.14	25.42±7.47	Wilcoxon	0.286
	Oiliness	1	37.69±12.04	36.98±11.23	Wilcoxon	0.169
	Oiliness	5	37.69±12.04	36.88±11.67	Wilcoxon	0.046
	Oiliness	10	37.69±12.04	37.17±10.95	Wilcoxon	0.131
	Elasticity	1	1.02±0.17	1.02±0.17	McNemar	0.500
	Elasticity	5	1.02±0.17	1.11±0.32	McNemar	0.125
	Elasticity	10	1.02±0.17	1.02±0.17	McNemar	0.500
Right palm of the hand	pH	1	6.49±0.30	6.47±0.32	*t* paired	0.672
	pH	5	6.49±0.30	6.45±0.30	*t* paired	0.427
	pH	10	6.49±0.30	6.53±0.28	*t* paired	0.541
	Moisture	1	28.27±8.12	25.57±7.11	Wilcoxon	0.000*
	Moisture	5	28.27±8.12	27.89±10.46	Wilcoxon	0.004*
	Moisture	10	28.27±8.12	26.90±9.31	Wilcoxon	0.001*
	Oiliness	1	35.49±13.10	38.44±10.53	Wilcoxon	0.526
	Oiliness	5	35.49±13.10	35.67±11.45	Wilcoxon	0.132
	Oiliness	10	35.49±13.10	36.60±11.23	Wilcoxon	0.432
	Elasticity	1	1.30±0.46	1.02±0.17	McNemar	0.005*
	Elasticity	5	1.30±0.46	1.11±0.32	McNemar	0.044*
	Elasticity	10	1.30±0.46	1.11±0.32	McNemar	0.031*
Left palm of the hand	pH	1	6.651±0.28	6.37±0.46	*t* paired	0.052
	pH	5	6.651±0.28	6.41±0.27	*t* paired	0.061
	pH	10	6.651±0.28	6.47±0.32	*t* paired	0.581
	Moisture	1	28.73±8.89	27.69±14.26	Wilcoxon	0.001*
	Moisture	5	28.73±8.89	26.20±7.96	Wilcoxon	0.002*
	Moisture	10	28.73±8.89	26.29±8.79	Wilcoxon	0.000*
	Oiliness	1	35.84±11.36	37.54±10.77	Wilcoxon	0.662
	Oiliness	5	35.84±11.36	36.93±10.84	Wilcoxon	0.597
	Oiliness	10	35.84±11.36	36.60±11.23	Wilcoxon	0.299
	Elasticity	1	1.30±0.46	1.05±0.23	McNemar	0.016*
	Elasticity	5	1.30±0.46	1.08±0.28	McNemar	0.027*
	Elasticity	10	1.30±0.46	1.08±0.28	McNemar	0.018*

It continue...

Table 4. Continuation.

	Variable	Time (days)	Baseline (before use, D0) Mean±SD	Post-use: Mean±SD	Test	*p*- value
Right dorsum of the hand	pH	1	6.51±0.26	6.48±0.31	*t* paired	0.851
	pH	5	6.51±0.26	6.42±0.32	*t* paired	0.231
	pH	10	6.51±0.26	6.47±0.31	*t* paired	0.752
	Moisture	1	25.87±8.55	25.06±7.54	Wilcoxon	0.085
	Moisture	5	25.87±8.55	25.72±8.21	Wilcoxon	0.130
	Moisture	10	25.87±8.55	25.51±7.51	Wilcoxon	0.300
	Oiliness	1	37.89±11.97	36.89±11.31	Wilcoxon	0.073
	Oiliness	5	37.89±11.97	36.59±11.50	Wilcoxon	0.004*
	Oiliness	10	37.89±11.97	37.04±11.01	Wilcoxon	0.158
	Elasticity	1	1.06±0.24	1.02±0.17	McNemar	0.375
	Elasticity	5	1.06±0.24	1.11±0.32	McNemar	0.500
	Elasticity	10	1.06±0.24	1.05±0.23	McNemar	0.500
Left dorsum of the hand	pH	1	6.51±0.27	6.48±0.38	*t* paired	0.500
	pH	5	6.51±0.27	6.44±0.34	*t* paired	0.118
	pH	10	6.51±0.27	6.47±0.27	*t* paired	0.326
	Moisture	1	25.87±7.99	25.06±7.40	Wilcoxon	0.002*
	Moisture	5	25.87±7.99	25.99±8.92	Wilcoxon	0.003*
	Moisture	10	25.87±7.99	25.46±7.79	Wilcoxon	0.003*
	Oiliness	1	37.79±11.39	36.70±11.59	Wilcoxon	0.004*
	Oiliness	5	37.79±11.39	37.04±11.47	Wilcoxon	0.004*
	Oiliness	10	37.79±11.39	37.20±11.28	Wilcoxon	0.003*
	Elasticity	1	1.00±0.00	1.02±0.17	McNemar	0.500
	Elasticity	5	1.00±0.00	1.02±0.17	McNemar	0.500
	Elasticity	10	1.00±0.00	1.02±0.17	McNemar	0.500

D0: day zero; SD: Standard Deviation.
* Statistically significant p-value ≤ 5% (p ≤ 0.05
Source: The authors.

Moisture

Statistical significance in moisture assessment was observed in the right palm of the hand (RPH) across all evaluations: between baseline D0 and D0 after cream application ($p < 0.001$), between D0 and D5 ($p = 0.004$), and between D0 and D10 ($p < 0.001$); in the left palm of the hand (LPH), across all comparisons: between baseline D0 and D0 after cream application ($p < 0.001$), between D0 and D5 ($p = 0.002$), and between D0 and D10 ($p < 0.001$); and in the left dorsum of the hand (LDH), across all comparisons: between baseline D0 and D0 after cream application (p = 0.002), between D0 and D5 ($p = 0.003$), and between D0 and D10 (p=0,003).

Oiliness

Regarding oiliness, statistically significant differences were observed in the right dorsum of the hand (RDH) between D0 and D5 ($p = 0.004$), and in the left dorsum of the hand (LDH) across all comparisons: between baseline D0 and D0 after cream application ($p = 0.004$), between D0 and D5 ($p = 0.004$), and between D0 and D10 (p=0,003).

Elasticity

Regarding elasticity, statistical significance was observed in the right dorsum of the hand (RDH) between baseline D0 and D0 after the first cream application ($p = 0.005$), between baseline D0 and D5 (p = 0.044), and between D0 and

D10 (p = 0.031); and in the left dorsum of the hand (LDH) between baseline D0 and D0 after the first cream application (p = 0.016), between D0 and D5 (p = 0.027), and between D0 and D10 (p=0,018).

DISCUSSION

Healthy skin functions as a barrier against various external microorganisms, ultraviolet (UV) radiation, and other threats. However, diabetes mellitus promotes a process known as glycation, in which excess blood glucose binds to proteins such as collagen and elastin, leading to the formation of AGEs. In the study by Moraes et al., a higher elasticity rate was observed in patients without a diagnosis of DM, as well as a greater incidence and depth of wrinkles in patients with DM, indicating more pronounced skin involvement in this group. [17]

The findings of the present study reinforce this observation. Regarding elasticity, nearly all evaluated sites showed results indicative of low local elasticity. On the first day (D0), in 30 or more patients, the predominant result was classified as poor (red indicator), except for the right dorsum of the foot, in which 27 patients showed poor results and 7 showed good results.

The epidermal barrier is composed primarily of the stratum corneum, which consists of corneocytes surrounded by lamellar lipid structures. Although the exact mechanisms of dysfunction are not fully understood, DM clearly impairs the epidermal barrier. Reduced macrovascular flow and decreased activity of sweat gland receptors have been observed, manifestations that may represent early signs of peripheral neuropathy. These alterations result in skin dryness, impaired perspiration, and fissure formation, thereby facilitating skin infections. Such impairments directly contribute to reduced skin moisture, while hyperglycemia itself is also a factor compromising the skin barrier. [18]

The skin of patients with DM tends to become more rigid, which may lead to pain and limited mobility, particularly affecting joints, especially the interphalangeal joints. Although treatment is available for most skin conditions affecting these patients, glycemic control may help prevent worsening complications. [19–23] Many skin alterations observed in patients with DM resemble changes associated with skin aging. A study conducted by Yoon et al. demonstrated this process, showing greater damage related to elasticity loss in patients with DM, as well as a high rate of desquamation. [24] The elasticity findings in the present study corroborate those reported by Moraes et al., who also observed similar results. [17]

Studies have also shown elevated skin pH in patients with DM compared with individuals without hyperglycemia. This increase impairs skin homeostasis by delaying permeability barrier restoration and reducing sebum production, thereby decreasing skin oiliness. [12]

Considering the findings from the evaluated regions of the upper limbs, namely the center of the dorsum and palm of the hands and the forearm, the mean skin pH ranged from 6.37 to 6.42 across the assessment days, with an overall mean of 6.48. In the lower limb regions, including the center of the dorsum and plantar surface of the feet, heel, and leg, pH values ranged from 6.47 to 6.63, with an overall mean of 6.54. These values corroborate the findings of the study by Dorf et al., which reported elevated pH parameters in this patient group, given that the average pH of healthy skin ranges from 5.4 to 5.9. [12]

Regarding oiliness, mean values in the center of the dorsum and plantar surface of the feet, heel, and leg ranged from 35.84% to 38.10% (mean: 36.90%). In the dorsum and palm of the hands and the forearm, mean values ranged from 35.44% to 38.44% (mean: 36.90%). These findings indicate increased local oiliness when compared with the DSA reference parameters (23–33% for the face and 16–22% for the palmar region and arms). [13]

Moisture in the upper limb regions showed mean values ranging from 25.06% to 29.29% (mean: 26.43%), whereas in the lower limbs values ranged from 24.76% to 27.47% (mean: 25.93%). Compared with the DSA reference ranges (40–60% for the face and 40–65% for the palmar region and arms), a predominance of skin with low moisture and high oiliness was observed [13].

Glycemic control is essential to prevent the onset and progression of skin lesions, both in acute and chronic stages. Health professionals, particularly nurses, should carefully assess the skin of patients with DM to prevent damage. The origin of lesions may not be exclusively related to poor glycemic control; however, this condition constitutes an aggravating factor and increases susceptibility to lesion progression. [19–21]

Another study, conducted by Chen et al., demonstrated that elevated glycated hemoglobin (HbA1c) levels may be associated with skin stiffening, showing a clear relationship between increased HbA1c levels and biophysical skin alterations. The study also highlighted the use of noninvasive devices and methods for skin assessment due to their high accuracy and lower subjectivity when compared with invasive procedures such as biopsies. [25]

Peripheral neuropathy (PN) is closely associated with DM and is common among these patients. Crăciun et al., in a sample of 57 patients, identified this condition in 31 individuals. Furthermore, they found that skin moisture was negatively associated with PN, as were oiliness parameters. Elasticity, in turn, was negatively associated with increasing age and the presence of DM. [26]

The limited number of studies evaluating healthy skin in individuals with DM, in the absence of lesions, complications, or deformities, hinders a broader understanding of the importance of these findings. There is a scarcity of literature investigating parameters such as pH, moisture, oiliness, and elasticity in healthy skin among individuals with DM. [13,26–28]

A tendency toward low adherence to preventive care among individuals with DM has been observed, particularly among males, who often seek healthcare services only after complications arise. [29] The findings of the present study corroborate the literature, as among the 34 participants, only a minority (five individuals) were male. A predominance of type 2 DM was also observed, consistent with the literature indicating that DM2 accounts for more than 90% of cases. Furthermore, participants were predominantly older than 60 years, the age group with the highest incidence of DM2.[30,31]

When the skin maintains a balance among moisture, oiliness, elasticity, and pH, there is a greater likelihood of preventing conditions such as lesions, fissures, and infections. The assessment of these parameters may contribute to strategies aimed at preventing DM-related skin complications, thereby reducing costs and morbidity associated with complications that are often irreversible [32-34].

Study Limitations

Difficulty in identifying and recruiting patients able to participate in all three assessment sessions constituted a limiting factor, which was further aggravated by the resistance of some nursing professionals toward academic research conducted within the healthcare units, despite authorization from the Municipal Health Department.

Recommendations

Advances in knowledge regarding skin biometry, including parameters such as moisture, elasticity, oiliness, and pH across different sites of the upper and lower limbs, open perspectives for the application of new products aimed at promoting skin balance, with potential benefits in the prevention of skin disorders in individuals with diabetes *mellitus*.

CONCLUSION

Skin biometry demonstrated improvements in moisture, oiliness, elasticity, and pH parameters in the center of the dorsum and palm of the hands and forearm, as well as in the center of the dorsum and plantar surface of the feet, heel, and leg, bilaterally, when D0 and D10 assessments were compared after 10 days of use of the 10% urea cream. The findings indicate potential improvement associated with the application of the 10% urea cream and routine hygiene guidance. This study opens perspectives for future research evaluating specific anatomical areas in isolation, over longer periods, and with other products.

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REFERENCES

1. ElSayed NA, Aleppo G, Aroda VR, Bannuru RR, Brown FM, Bruemmer D, et al. Classification and diagnosis of diabetes: standards of care in diabetes–2023. Diabetes Care. 2023;46(Suppl 1):S19-40. https://doi.org/10.2337/dc23-S002
2. American Diabetes Association Professional Practice Committee. Diagnosis and classification of diabetes: standards of care in diabetes–2025. Diabetes Care. 2025;48(1 Suppl 1):S27-49. https://doi.org/10.2337/dc25-S002
3. International Diabetes Federation. Rare forms of diabetes [Internet]. Brussels: IDF; 2025 [citado em 20 ago. 2025]. Available at: https://idf.org/about-diabetes/rare-types-of-diabetes/
4. International Diabetes Federation. IDF Diabetes Atlas. 10th ed [Intertnet]. Brussels: International Diabetes Federation; 2024 [citado em 20 ago. 2025]. Available at: https://profissional.diabetes.org.br/wp-content/uploads/2022/02/IDF_Atlas_10th_Edition_2021-.pdf
5. World Health Organization. Diabetes [Internet]. Geneva: WHO; 2023 [citado em 22 ago. 2025]. Available at: https://www.who.int/news-room/fact-sheets/detail/diabetes
6. Gregg EW, Pratt A, Owens A, Barron E, Dunbar-Rees R, Slade ET, et al. The burden of diabetes-associated multiple long-term conditions on years of life spent and lost. Nat Med. 2024;30(10):2830-7. https://doi.org/10.1038/s41591-024-03123-2
7. Sociedade Brasileira de Diabetes. Diretriz Oficial da Sociedade Brasileira de Diabetes 2022–2023 [Internet]. São Paulo: Clannad; 2022 [cited on Aug. 20, 2025]. Available at: https://diretriz.diabetes.org.br/data/2022/
8. Sousa JVA, Miquelino ACC, Lino LAM, Souza DMST. Prevenção da doença do pé relacionada ao diabetes mellitus: perfil clínico e fatores associados. Arace. 2026;8(2):e12335. https://doi.org/10.56238/arev8n2-116
9. Voegeli D. The effect of washing and drying practices on skin barrier function. J Wound Ostomy Continence Nurs. 2008;35(1):84-90. https://doi.org/10.1097/01.WON.0000308623.68582.d7
10. Man MQ, Wakefield JS, Mauro TM, Elias PM. Alterations in epidermal function in type 2 diabetes: implications for the management of this disease. J Diabetes. 2022;14(9):586-95. https://doi.org/10.1111/1753-0407.13303
11. Lambers H, Piessens S, Bloem A, Pronk H, Finkel P. Natural skin surface pH is on average below 5, which is beneficial for its resident flora. Int J Cosmet Sci. 2006;28(5):359-70. https://doi.org/10.1111/j.1468-2494.2006.00344.x
12. Dorf N, Maciejczyk M. Skin manifestations in diabetes–what is new? Front Med (Lausanne). 2025;12:1640144. https://doi.org/10.3389/fmed.2025.1640144
13. SkinUp Beauty Devices. Como está a minha pele hoje? Skin Analyser Digital: facial e corporal [Internet]. Skinup; 2022 [citado em 01 mar. 2023]. Available at: https://meuskinup.com.br/downloads/manual-instrucoes-skinup.pdf
14. Rosner B. Fundamentals of biostatistics. 8th ed. Boston: Cengage Learning; 2016.

15. Altman DG. Practical statistics for medical research. London: Chapman and Hall; 1991.

16. Armitage P, Berry G, Matthews JNS. Statistical methods in medical research. 4th ed. Oxford: Blackwell Science; 2002.

17. Moraes VR, Melo MO, Maia Campos PMBG. Evaluation of morphological and structural skin alterations on diabetic subjects by biophysical and imaging techniques. Life (Basel). 2023;13(2):579. https://doi.org/10.3390/life13020579

18. Bogusz-Górna K, Polańska A, Dańczak-Pazdrowska A, Żaba R, Fichna P, Kędzia A. Selected parameters of epidermal barrier in juveniles with type 1 diabetes correspond with the severity of diabetes – an observational study. Front Endocrinol (Lausanne). 2025;16:1709604. https://doi.org/10.3389/fendo.2025.1709604

19. Lima AL, Illing T, Schliemann S, Elsner P. Cutaneous manifestations of diabetes mellitus: a review. Am J Clin Dermatol. 2017;18(4):541-53. https://doi.org/10.1007/s40257-017-0275-z

20. Al-Mutairi N, Zaki A, Sharma AK, Al-Sheltawi M. Cutaneous manifestations of diabetes mellitus. Study from Farwaniya hospital, Kuwait. Med Princ Pract. 2006;15(6):427-30. https://doi.org/10.1159/000095488

21. Abate MCMO, Aroucha PMT, Nóbrega DVM, Rocha IPM, Soares SD, Reis AA, et al. Einstein (Sao Paulo). 2025:23:eRW1193. https://doi.org/10.31744/einstein_journal/2025RW1193

22. American Diabetes Association Professional Practice Committee. 12. Retinopathy, Neuropathy, and Foot Care: Standards of Care in Diabetes-2024. Diabetes Care. 2024;47(Suppl 1):S231-S243. https://doi.org/10.2337/dc24-S012

23. Foss NT, Polon DP, Takada MH, Foss-Freitas MC, Foss MC. Skin lesions in diabetic patients. Rev Saúde Pública 2005;39(4):677-82.

24. Yoon HS, Baik SH, Oh CH. Quantitative measurement of desquamation and skin elasticity in diabetic patients. Skin Res Technol. 2002;8(4):250-4. https://doi.org/10.1034/j.1600-0846.2002.00332.x

25. Chen F, Zhou J, Chen X, Deng X, Zhou J, Pan X, et al. Association between glycated hemoglobin and biomechanical properties of the skin with type 2 diabetes by using an electro-mechanical skin device. Front Endocrinol (Lausanne). 2025;16:1580193. https://doi.org/10.3389/fendo.2025.1580193

26. Crăciun AE, Moldovan M, Rusu A, Niță C, Crăciun C, Tătaru A. Predictors of changes in physical properties of skin in patients with diabetes mellitus. Rom J Diabetes Nutr Metab Dis. 2012;19(1):33-40. https://doi.org/10.2478/v10255-012-0005-5

27. Demirseren DD, Emre S, Akoglu G, Arpacı D, Arman A, Metin A, et al. Relationship between skin diseases and extracutaneous complications of diabetes mellitus: clinical analysis of 750 patients. Am J Clin Dermatol. 2014;15(1):65-70. https://doi.org/10.1007/s40257-013-0048-2

28. Kalyani RR, Saudek CD, Brancati FL, Selvin E. Association of diabetes, comorbidities, and A1C with functional disability in older adults: results from the National Health and Nutrition Examination Survey (NHANES), 1999–2006. Diabetes Care. 2010;33(5):1055-60. https://doi.org/10.2337/dc09-1597.

29. Boyle JP, Thompson TJ, Gregg EW, Barker LE, Williamson DF. Projection of the year 2050 burden of diabetes in the US adult population: dynamic modeling of incidence, mortality, and prediabetes prevalence. Popul Health Metr. 2010;8:29. https://doi.org/10.1186/1478-7954-8-29

30. American Diabetes Association Professional Practice Committee. Diagnosis and classification of diabetes: standards of care in diabetes – 2024. Diabetes Care. 2024;47(Suppl 1):S20-42. https://doi.org/10.2337/dc24-S002.

31. Rajkumar J, Chandan N, Lio P, Shi V. The skin barrier and moisturization: function, disruption, and mechanisms of repair. Skin Pharmacol Physiol. 2023;36(4):174-85. https://doi.org/10.1159/000534136

32. Baker P, Huang C, Radi R, Moll SB, Jules E, Arbiser JL. Skin barrier function: the interplay of physical, chemical, and immunologic properties. Cells. 2023;12(23):2745. https://doi.org/10.3390/cells12232745

33. Lima LJL, Lopes MR, Botelho Filho CAL, Cecon RS. Avaliação do autocuidado com os pés entre pacientes portadores de diabetes melito. J Vasc Bras. 2022;21:e20210011. https://doi.org/10.1590/1677-5449.210011

34. Oliveira AF, De Marchi ACB, Leguisamo CP, Blado GV, Wawginiak TA. Estimativa do custo de tratar o pé diabético, como prevenir e economizar recursos. Ciênc Saúde Colet. 2014;19(6):1663-71. https://doi.org/10.1590/1413-81232014196.09912013