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Research Article

Screening of diabetic neuropathy and ulcer risk in Primary Health Care using a mobile application

Estudo de rastreio de neuropatia diabética e risco de úlcera na Atenção Primária em Saúde utilizando um aplicativo para dispositivos móveis

Estudio de cribado de neuropatía diabética y riesgo de úlcera en atención primaria en salud mediante una aplicación para celular

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Abstract

Introduction: Diabetes mellitus (DM) is a chronic condition that can cause damage to multiple organs, leading to the development of complications and increased morbidity and mortality. Diabetic polyneuropathy (DPN) is currently the most prevalent chronic complication of DM, making it essential to implement strategies for the early detection of DPN and the risk of developing diabetic foot — a complication characterized by a wound (ulcer) in the lower limbs aggravated by infection, which may also include any neurological, orthopedic, or vascular alteration affecting this region of the body. Approximately 85% of amputations in individuals with diabetes could be prevented through measures such as early detection, prevention, and intervention in ulcers. **Objective:** To detect, through the use of a screening tool — the SISPED® application (*Diabetic Foot System*) — the presence of DPN, to stage the risk for ulcer development, and to evaluate the usability of the application. **Methods:** A prospective, analytical, and longitudinal study was conducted with individuals with DM aged over 18 years who underwent foot assessment using the SISPED® tool. Descriptive analysis was performed using frequency tables for categorical variables and measures of central tendency and dispersion for continuous variables. The chi-square test or Fisher's exact test was used to compare proportions. The Mann–Whitney test was applied for comparison of continuous variables between two groups, and the Kruskal–Wallis test for comparisons among four groups. A p-value <0.05 was considered statistically significant. **Results:** A total of 203 individuals had their feet evaluated. There was a predominance of females aged between 50 and 79 years, with approximately 11 years since DM diagnosis, a mean glycated hemoglobin (HbA1c) level of 8%, use of oral medications, and associated hypertension. The prevalence of neuropathy was 31%. Age, DM duration greater than 10 years, and the Neuropathy Symptom Score (NSS) and Neuropathy Impairment Score (NIS) were significantly associated with the presence of DPN. The presence of vasculopathy and altered plantar sensitivity were associated with a higher risk of ulcer development. The usability of the SISPED® application, assessed using the System Usability Scale (SUS®), was rated as moderate by the medical students who applied the instrument. **Conclusions:** the study showed a high prevalence of PND and a high prevalence of moderate and high risks for the development of ulcers. The usability found among medical students was considered moderate.
Keywords: Diabetes mellitus; Diabetic neuropathies; Diabetic foot.

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Resumo

Introdução: O Diabetes Mellitus (DM) é uma condição crônica que pode causar danos a vários órgãos do corpo, levando ao desenvolvimento de complicações e aumento da morbimortalidade. A Polineuropatia Diabética (PND) é atualmente a complicação crônica mais prevalente do DM, sendo fundamental que estratégias sejam implementadas para detecção precoce da PND e do risco de desenvolver pé diabético – complicação caracterizada por uma ferida (úlcera) nos membros inferiores agravada por uma infecção, que também pode englobar qualquer alteração de origem neurológica, ortopédica ou vascular que afete essa região do corpo. Cerca de 85% das amputações em diabéticos poderiam ser prevenidas mediante ações como detecção precoce, prevenção e intervenção nas úlceras. **Objetivo:** Detectar, por meio da utilização de um instrumento de rastreio – o aplicativo SISPED® (Sistema do Pé Diabético) –, a presença de PND, estadiar o risco para o desenvolvimento de úlceras e avaliar a usabilidade do aplicativo. **Métodos:** Estudo prospectivo, analítico e longitudinal realizado em pessoas com DM acima de 18 anos que foram submetidas à avaliação dos pés por meio da ferramenta SISPED®. Foi realizada uma análise descritiva com tabelas de frequência para variáveis categóricas, e medidas de posição e dispersão para variáveis contínuas. Para comparação de proporções foi utilizado o teste qui-quadrado ou teste exato de Fisher. Para comparação de medidas contínuas entre dois grupos foi aplicado o teste de Mann-Whitney e entre quatro grupos, o teste de Kruskal-Wallis. Um valor p abaixo de 0,05 foi considerado significativo. **Resultados:** Duzentas e três pessoas tiveram seus pés avaliados. Houve predomínio de indivíduos do sexo feminino, entre 50 e 79 anos, com cerca de 11 anos de diagnóstico de DM, com uma média de hemoglobina glicosilada (HbA1c) de 8%, em uso de drogas orais e com hipertensão associada. A prevalência de neuropatia foi de 31%; a idade, o tempo de DM acima de 10 anos, e os Escores de Sintomas Neuropáticos (ESN) e de Comprometimento Neuropático (ECN) foram significativamente relacionados com a presença de PND. A presença de vasculopatia e a sensibilidade plantar alterada foram relacionadas ao maior risco para o desenvolvimento de úlceras. A usabilidade do aplicativo SISPED®, obtida por meio da ferramenta *System of Usability Scale* (SUS®), foi considerada regular pelos acadêmicos de Medicina que aplicaram o instrumento. **Conclusões:** O estudo evidenciou uma alta prevalência de PND e de riscos moderados e altos para o desenvolvimento de úlceras. A usabilidade encontrada entre acadêmicos de Medicina foi considerada regular.

Palavras-chave: Diabetes mellitus; Neuropatia diabética; Pé diabético.

Resumen

Introducción: La diabetes mellitus (DM) es una condición crónica que, cuando no se controla, puede causar daños en diversos órganos del cuerpo, lo que lleva al desarrollo de complicaciones y al aumento de la morbimortalidad. La polineuropatía diabética (PND) es actualmente la complicación crónica más prevalente de la DM, la enfermedad más infradiagnosticada y más infratratada, es fundamental que se implementen estrategias para la detección temprana de la PND y el riesgo de desarrollar pie diabético, complicación de la DM caracterizada por una herida (úlcera) en los miembros inferiores agravada por una infección, pero también puede englobar cualquier alteración de origen neurológico, ortopédico o vascular que afecte a esta región del cuerpo. Cerca del 85% de las amputaciones en diabéticos podrían prevenirse mediante acciones como la detección precoz, prevención e intervención en úlceras. **Objetivo:** detectar la presencia de DPN y estadificar el riesgo para el desarrollo de úlceras, mediante el uso de un instrumento de tamizaje, la aplicación SISPED®, y evaluar la usabilidad de la aplicación. **Métodos:** Estudio prospectivo, analítico y longitudinal realizado en personas con DM mayores de 18 años a quienes se les realizó evaluación del pie mediante la herramienta SISPED®. Se realizó un análisis descriptivo mediante tablas de frecuencia para variables categóricas y medidas de posición y dispersión para variables continuas. Para comparar proporciones se utilizó la prueba de chi-cuadrado o la prueba exacta de Fisher. Para comparar medidas continuas entre 2 grupos, se aplicó la prueba de Mann-Whitney y entre 4 grupos, la prueba de Kruskal-Wallis, se consideró significativo un valor de p por debajo de 0,05. **Resultados:** Se evaluaron los pies a 203 personas, hubo predominio del sexo femenino, entre 50 y 79 años, con cerca de 11 años de diagnóstico de DM, con un promedio de 8% de hemoglobina glicosilada (HbA1c), utilizando fármacos por vía oral y con hipertensión. La prevalencia de neuropatía fue del 31%, la edad, el tiempo de DM durante 10 años y las puntuaciones de síntomas neuropáticos (NSE) y deterioro neuropático (NEC) se relacionaron significativamente con la presencia de PND. La presencia de vasculopatía y sensibilidad plantar alterada se relacionaron con mayor riesgo para el desarrollo de úlceras. La usabilidad de la aplicación SISPED®, obtenida a través de la herramienta SUS®, fue considerada regular por los estudiantes de medicina que aplicaron el instrumento. **Conclusiones:** el estudio mostró una alta prevalencia de DPN y una alta prevalencia de riesgos moderados y altos para el desarrollo de úlceras. La usabilidad encontrada entre los estudiantes de medicina se consideró regular.

Palabras clave: Diabetes mellitus; Neuropatías diabéticas; Pie diabético.

INTRODUCTION

Diabetes mellitus (DM) is a chronic condition characterized by elevated blood glucose levels resulting from varying degrees of impaired insulin secretion, commonly associated with peripheral insulin resistance. Persistent hyperglycemia may lead to damage in multiple organ systems, contributing to the development of disabilities, health complications, and increased morbidity and mortality.[1]

An increase in the prevalence of type 2 diabetes mellitus (DM2) has been observed across all world regions.[1,2] Currently, approximately 537 million individuals, corresponding to 10.5% of the global population, are living with DM. The COVID-19 pandemic further exacerbated this scenario, as social isolation directly affected the care and management of these individuals. This impact is attributed both to the increased risk of developing more severe pulmonary manifestations of the disease and to disruptions in healthcare follow-up, resulting in inadequate monitoring and poor glycemic control.[1,3]

Diabetic polyneuropathy (DPN), currently the most prevalent, underdiagnosed, and undertreated chronic complication of DM, presents a prevalence ranging from 13 to 47% in population-based and outpatient studies.[4] The implementation of strategies for the early detection of DPN and the identification of individuals at risk for developing diabetic foot is essential, given that approximately 85% of diabetes-related amputations could be prevented through measures such as early diagnosis, preventive interventions, and prompt management of ulcers.[5]

In Brazil, Primary Health Care (PHC), the main entry point to the Unified Health System (*Sistema Único de Saúde* – SUS), organizes the healthcare network across its different levels. Care delivery is predominantly structured through the Family Health Strategy (FHS) and has undergone significant transformation over the past two decades, shifting from a reactive, demand-driven model — characterized by care in response to patients' complaints and expectations — to a proactive, population-based approach — in which healthcare professionals are responsible for actively identifying individuals at risk and implementing appropriate interventions.[6] It is estimated that approximately 80 to 85% of the general population's health needs are resolved within PHC. Accordingly, PHC is expected to play a central role in the early detection and appropriate management of individuals at increased risk of developing diabetic foot.[7] In the municipality of Rondonópolis, where this study was conducted, approximately 12 health units are supported by the School of Medicine of Universidade Federal de Rondonópolis (UFR). Within these programs, care is delivered through supervised clinical activities involving medical students and faculty members.

The integration of digital technologies into healthcare has become an increasingly widespread global reality. Patients, institutions, and healthcare professionals have been using mobile applications to connect contexts, users, and knowledge, as well as to expand strategies in which care and education are integrated.[6] The SISPED® (Diabetic Foot System) application, developed in 2006 by Universidade Federal do Sergipe, is intended to support the early diagnosis of DPN and the identification of individuals at risk of developing this condition.[8] It is essential to assess whether such applications are sufficient to ensure effectiveness, efficiency, and validity in the use of the technological resources they provide.[9]

Mobile application usability encompasses the assessment of ease of use, that is, how individuals interact with a system, typically measured using validated instruments, as well as the extent to which a program/application can be understood and operated by users to achieve its intended purpose.[10] The System Usability Scale (SUS®), one of the most widely used and straightforward tools for evaluating system usability, is a standardized instrument that is easy for users to complete. It assesses the effectiveness with which users achieve their objectives, the effort and resources required, and overall satisfaction with the user experience.[8,9]

SUS® consists of ten items answered on a Likert scale ranging from 1 to 5, where 1 = "strongly disagree" and 5 = "strongly agree."[8] To analyze the results, an overall score must be calculated: participants' responses for each item are converted into new values, summed, and then multiplied by 2.5, yielding a total score ranging from 0–40 to 0–100. Although expressed on a scale from 0 to 100, these scores do not

represent percentages and should be interpreted according to percentile-based classifications. According to the literature, SUS® scores above 90 indicate best imaginable usability; scores between 80 and 90, excellent usability; between 70 and 80, good usability; between 60 and 70, fair usability; and below 60, unacceptable usability.[8] Therefore, the objectives of this study were to detect the presence of DPN and to stratify the risk of ulcer development using a screening instrument (the SISPED® application) in a sample of individuals with DM followed in Family Health Units (FHU) and assisted by the School of Medicine of UFR, as well as to evaluate the usability of the application among medical students.

METHODOLOGY

Study Design and Population

This is a prospective, analytical, and longitudinal study conducted between 2019 and 2022, involving individuals aged over 18 years with DM who were followed at FHUs in the municipality of Rondonópolis. The selected participants underwent foot assessment using the SISPED® application. The usability of the application, assessed using SUS®, was evaluated based on responses provided by medical students from UFR, who were responsible for administering the SISPED® instrument to the participants.

Study Procedures

The SISPED® instrument was administered by the researcher and by fourth- and fifth-year medical students from the participating health units, who received specific training from the principal investigator. The application automatically generates a report of the collected data in a spreadsheet format. A descriptive analysis was performed using frequency distributions for categorical variables and measures of central tendency and dispersion for continuous variables (mean, standard deviation [SD], median, minimum, and maximum values). The test or Fisher's exact test was used, when appropriate, to compare proportions. The Mann-Whitney test was applied to compare continuous variables between two groups, and the Kruskal-Wallis test for comparisons among four groups. The level of significance adopted for all statistical analyses was 5%.

Responses from medical students to SUS® were collected through an online questionnaire administered via Google Forms® and subsequently entered into a dedicated spreadsheet for SUS® score calculation.

Ethical safeguards for research participants were ensured, as the study was approved by a Research Ethics Committee involving human subjects, and all participants provided written informed consent.

RESULTS

A total of 203 individuals with DM underwent foot assessment using the SISPED® application for the detection of neuropathy; of these, 96 were evaluated for the risk of ulcer development. Ninety medical students participated in the assessments, and 39 completed the SUS® instrument.

Table 1 presents the general descriptive characteristics of the evaluated participants, indicating a predominance of female individuals aged between 50 and 79 years, with a mean duration of DM of

Table 1. General descriptive analysis.

Characteristic	
Age (mean ± standard deviation (SD) (n: number of individuals)	63.3 years ± 12.71 (n=203)
Male	37% (n=75)
Female	63% (n=128)
Age range	
<39 years	3.0% (n=6)
39–59 years	31% (n=62)
59–79 years	61% (n=123)
>79 years	6% (n=12)
Mean duration of DM (mean ± SD)	11.66±8.90 (n=198)
Duration of DM	
<5 years	30% (n=59)
5–10 years	23% (n=46)
10-20 years	31% (n=61)
> than 20 years	16% (n=31)
Fasting blood glucose (mean ± SD)	161.9 +/- 86.8 (n=104)
Last glycated hemoglobin (HbA1c) (mean ± SD)	8.03 +/- 1.99 (n=51)
HbA1c categories	
<7%	41.2% (n=21)
7–10%	43.2% (n=24–46)
>10%	15.7% (n=8)
Characteristic	
Type of DM	
Type 1:	2% (n=4)
Type 2:	98% (n=200)
Type of treatment	
OD: oral drugs	74% (n=150)
Oral drugs and insulin	14% (n=28)
Diet only	5% (n=10)
Insulin only	7% (n=15)
Alcohol consumption	Present: 20.5% (n=41) Absent: 79.5% (n=159)
Smoking	Present: 13.9% (n=28) Absent: 86.1% (n=173)
Hypertension	Present: 75.9% (n=154) Absent: 24.1% (n=49)
Previous acute myocardial infarction (AMI)	Present: 13.9% (n=28) Absent: 86.1% (n=173)
Treatment for retinopathy	Present: 20.9% Absent: 79.1%
Presence of neuropathy after evaluation	Present: 31% (n = 63) Absent: 69% (n = 140)

DM: Diabetes Mellitus.

approximately 11 years and a mean glycated hemoglobin level of 8.03%. Most participants had DM2, were receiving oral pharmacological treatment, and had concomitant hypertension. The prevalence of neuropathy in the study population was 31%.

Table 2 presents the descriptive analysis and comparisons according to the presence or absence of neuropathy. Particular attention is drawn to the variables that demonstrated a statistically significant association with the presence of DPN: age (approximately six years higher compared with individuals without neuropathy); duration of DM greater than ten years; reduced or absent vibratory sensation; reduced or absent pain sensation; reduced or absent thermal sensation; and a predominance of symptoms such as burning, numbness, or tingling, primarily localized in the feet.

Table 3 presents the descriptive analysis and comparisons among the different risk factors for ulcer development, highlighting the following variables as significantly associated with at-risk feet: abnormal palpation of the right and left posterior tibial pulses, abnormal right and left dorsalis pedis pulses, and impaired monofilament sensitivity in both feet.

Table 4 presents the usability results of the SISPED® application, as assessed by SUS®, with a mean score of 60.83 points, indicating fair usability in the evaluation of the application.

DISCUSSION OF RESULTS

The use of the SISPED® application enabled the detection of neuropathy and the identification of individuals at risk of developing ulcers among users with DM, with a prevalence of 31% for neuropathy and 30% for moderate to high ulcer risk in the selected sample. This finding is consistent with data reported in the literature, indicating a high prevalence of peripheral DPN among individuals with DM.[11] In Brazil, the Brazupa multicenter study[12], conducted in 19 specialized centers for the follow-up of individuals with DM across 10 states between 2012 and 2014, employed a methodology similar to that used in the present study. Among the 1,453 individuals evaluated, a neuropathy prevalence of approximately 34% was identified. In contrast to the present findings, that study reported a higher risk of foot ulcers among smokers, hypertensive individuals, and male participants.

The duration of disease associated with the highest prevalence of DPN was similar to that observed in the present study (10–15 years). However, a lower age among patients with moderate to severe neuropathic symptoms was not observed in this sample (58 years *vs*. 68 years). Other national studies,[13–16] employing similar methodologies, reported prevalence rates of 44, 27.5, 36.9, and 43.7%, respectively. A European multicenter cohort study, Eurodiale[17], conducted between 2003 and 2004 and including 1,088 individuals across 14 DM treatment centers, demonstrated that DPN is an independent predictor of ulcer persistence, increasing the likelihood of non-healing of ulcers in individuals with DM by approximately 2.3 times over a one-year follow-up period. The study also reported a sensitivity of 89% and a specificity of 100% for tests used to assess the Neuropathy Impairment Score (NIS), enabling the detection of alterations in both small and large nerve fibers and, consequently, identifying a higher risk for foot ulcer development. Similarly, the study by Sun J *et al.*[18], a meta-analysis including 29 studies and a total of 50,112 participants, reported a pooled prevalence of DPN of 30% (95% confidence interval, CI95% 25–34%).

It is noteworthy that, in the present study, approximately 42% of the evaluated individuals presented HbA1c values within recommended control targets (below 7%), and the mean value of 8.02% was lower than that reported in other studies. It is important to emphasize that this investigation was conducted at the primary care level, in contrast to most studies,[12,14] which were carried out in

Table 2. Descriptive analysis and comparisons between presence and absence of neuropathy.

Characteristic	Presence of neuropathy	Absence of neuropathy	p-value
Age (mean ± SD)	67.25±11.51 (n=63)	61.46±12.86 (n=140)	0.0038
Male	26 (41.3%)	49 (35.0%)	0.3919
Female	37 (58.7%)	91 (65.0%	0.3919
Age range			
<39 years	1 (1.6%)	5 (3.6%)	
39–59 years	13 (20.6%)	49 (62.2%)	
59–69 years	23 (36.5%)	55 (39.3%)	
69–79 years	19 (30.2%)	26 (18.6%)	
>79 years	7 (11.1%)	5 (3.6%)	
Duration of DM			0.0038
<5 years	10 (16.4%)	49 (**35.8**%)	
5–10 years	12 (19.7%)	34 (24.8%)	
10–15 years	13 (21.3%)	24 (17.5%)	
15–20 years	9 (14.8%)	15 (10.9%)	
20–25 years	6 (9.8%)	10 (7.3%)	
>25 years	11 (18.0%)	5 (3.6%)	
Fasting blood glucose (mean ± SD)	168.01±85.42	159.65±87.83	0.5309
Last glycated hemoglobin (mean ± SD)	8.68±2.40	7.67±1.65	0.2525
Alcohol consumption			0,5172
Present	11 (17.7%)	30 (21.7%)	
Absent	51 (82.3%)	108 (78.3%)	
Smoking			0.5477[2]
Present	10 (16.1%)	18 (12.9%)	
Absent	52 (83.9%)	121 (87.1%)	
Hypertension			0,0649
Present	53 (84.1%)	101 (72.1%)	
Absent	10 (15.9%)	39 (27.9%)	
Previous AMI			0.3288
Present	11 (17.5%)	17 (12.3%)	
Absent	52 (82.5%)	121 (87.7%)	
Previous treatment for retinopathy			
Present	20 (**31.7**%)	22 (15.9%)	0.1746
Absent	43 (68.3%)	116 (84.1%)	
Achilles reflex			
Normal	21 (**58.3**%)	21 (16.3%)	<.0001
Absent	5 (41.7%)	108 (**83.7**%)	
Vibratory sensation			
Present	21 (33.3%)	118 (85.5%)	<.0001
Reduced/Absent	42 (**66.7**%)	20 (14.5%)	
Pain sensation			<.0001
Present	23 (36.5%)	119 (**86.2**%)	
Reduced/Absent	40 (**63.5**%)	19 (13.8%)	
Thermal sensation			<.0001
Present	14(22.2%)	118 (**85.5**%)	
Reduced/Absent	49 (**77.8**%)	20 (14.5%)	
Predominant painful sensation			0.0005[2]
Burning, numbness, or tingling	40 (**85.1**%)	33 (53.2%)	
Fatigue, cramps, or itching	7 (14.9%)	29 (46.8%)	
Predominant location of sensation			0.0011
Feet	34 (**70.8**%)	22 (36.1%)	
Calves	11 (22.9%)	26 (42.6%)	
Others	3 (6.3%)	13 (21.3%)	

DM: Diabetes Mellitus; AMI: Acute Myocardial Infarction.

Table 3. Descriptive analysis and comparisons among different ulcer risk categories.

Characteristic	Very low risk	Low risk	Moderate risk	High risk	p-value
Age (mean ± SD)	65.89±5.30 (n=9)	63.69±11.91 (n=26)	69.65±13.32 (n=20)	63.22±12.33 (n=41)	0.3391
Male	6 (6,25%)	8 (8,33%)	8 (8,33%)	21 (21,87%)	0.2030
Female	3 (3,125%)	18 (18,75%)	12 (12,5%)	20 (20,83%)	
Fasting blood glucose (mean ± SD)	152.20±61.05 (n = 5)	139.74±40.39 (n=14)	152.27±73.20 (n=11)	162.55±90.05 (n=22)	0.9702
HbA1c (mean ± SD)	9.60 (n=1)	7.28±1.16 (n=4)	7.96±2.67 (n=8)	8.76±1.96 (n=14)	
Duration of DM (mean ± SD)	12.78±9.54 (n=9)	11.04±7.83 (n=26)	11.70±6.95 (n=20)	14.35±10.69 (n=40)	0.7571
Alcohol consumption					
Present	1 (11.1%)	4 (15.4%)	4 (20.0%)	9 (22.0%)	0.9067
Absent	8 (88.9%)	22 (84.6%)	16 (80.0%)	32 (78.0%)	
Smoking Present	2 (22.2%)	4 (15.4%)	4 (20.0%)	8 (19.5%)	0.9422
Absent	7 (77.8%)	22 (84.6%)	16 (80.0%)	33 (80.5%)	
Hypertension					
Present	7 (77.8%)	20 (76.9%)	14 (70.0%)	29 (70.7%)	0.9179
Absent	2 (22.2%)	6 (23.1%)	6 (30.0%)	12 (29.3%)	
Previous AMI Present	0 (0.0%)	1 (3.8%)	5 (25.0%)	5 (12.2%)	0.1281
Absent	9 (100.0%)	25 (96.2%)	15 (75.0%)	36 (87.8%)	
Treatment for retinopathy					
Present	2 (22.2%)	7 (26.9%)	8 (40.0%)	11 (26.8%)	0.6781
Absent	7 (77.8%)	19 (73.1%)	12 (60.0%)	30 (73.2%)	
Previous foot ulcer					
Yes	1 (11.1%)	0 (0.0%)	0 (0.0%)	34 (82.9%)	
No	8 (88.9%)	26 (100.0%)	20 (100.0%)	7 (17.1%)	
Previous amputation					
Yes	0 (0.0%)	0 (0.0%)	0 (0.0%)	11 (26.8%)	
No	9 (100.0%)	26 (100.0%)	20 (100.0%)	30 (73.2%)	
Appropriate footwear at evaluation?					
Yes	5 (55.6%)	12 (46.2%)	6 (30.0%)	10 (24.4%)	0.1466
No	4 (44.4%)	14 (53.8%)	14 (70.0%)	31 (75.6%)	
Altered right posterior tibial pulse (PT)					
Yes	9 (100.0%)	25 (96.2%)	11 (55.0%)	23 (56.1%)	0.0003
No	0 (0.0%)	1 (3.8%)	9 (45.0%)	18 (43.9%)	
Altered right dorsalis pedis pulse					
Yes	9 (100.0%)	25 (96.2%)	13 (65.0%)	27 (65.9%)	0.0031
No	0 (0.0%)	1 (3.8%)	7 (**35.0**%)	14 (34.1%)	
Altered left posterior tibial pulse (PT)					
Yes	9 (100.0%)	25 (96.2%)	9 (45.0%)	21 (51.2%)	<.0001
No	0 (0.0%)	1 (3.8%)	11 (55.0%)	20 (48.8%)	
Altered left dorsalis pedis pulse					
Yes	9 (100.0%)	25 (96.2%)	10 (50.0%)	23 (56.1%)	0.0002
No	0 (0.0%)	1 (3.8%)	10 (50.0%)	18 (43.9%)	
Altered monofilament sensation – right foot					
No altered points	9 (100.0%)	3 (11.5%)	2 (10.0%)	13 (31.7%)	0.0005
1 altered point	0 (0.0%)	5 (19.2%)	4 (20.0%)	4 (9.8%)	
2 altered points	0 (0.0%)	3 (11.5%)	4 (20.0%)	8 (19.5%)	
3 altered points	0 (0.0%)	15 (57.7%)	10 (50.0%)	16 (39.0%)	
Altered monofilament sensation – left foot					
No altered points	9 (100.0%)	3 (11.5%)	2 (10.0%)	12 (29.3%)	0.0003
1 altered point	0 (0.0%)	4 (15.4%)	2 (10.0%)	7 (17.1%)	
2 altered points	0 (0.0%)	3 (11.5%)	6 (30.0%)	7 (17.1%)	
3 altered points	0 (0.0%)	16 (61.5%)	10 (50.0%)	15 (36.6%)	

DM: Diabetes Mellitus.

Table 4. Usability assessment by students who participated in the study.

Questions	Mean
01. I think I would like to use this system frequently.	3.51
02. I found the system unnecessarily complex.	2.67
03. I found the system easy to use.	3.38
04. I think I would need the support of a person with technical knowledge to use the system.	2.36
05. I think the various functions in this system are well integrated.	3.21
06. I think the system has too much inconsistency.	2.69
07. I imagine that people will learn to use this system quickly.	3.49
08. I found the system cumbersome to use.	2.72
09. I felt confident using the system.	3.49
10. I needed to learn several things before I could get going with this system.	2.31
Adjusted mean	24.33
Mean x 2.5	60.83

referral centers for the management of individuals with diabetes. All assessments were conducted within the FHS, a setting characterized by multidisciplinary care. In this context, the role of Community Health Agents (CHA) is particularly relevant, as they identify individuals with diabetes during home visits and monitor them over time, assessing treatment adherence and lifestyle modifications (LSM), in addition to facilitating attendance at consultations and completion of requested examinations. This organizational structure may have contributed to more effective monitoring of individuals with chronic conditions.

Similar to other studies,[12,3] the present findings demonstrated a statistically significant association between duration of diagnosis and the presence of DPN. Both the Neuropathic Symptom Score (NSS) and NIS showed statistical significance in the assessment of diabetic peripheral neuropathy and in the evaluation of ulcer risk. These instruments are widely accessible across all levels of care, particularly in PHC, where the prevention of diabetic foot is essential to reduce the high incidence of ulcerations and amputations among individuals with the disease. Such measures may contribute to the optimization of public health expenditures and to improvements in patients' quality of life.[19]

Both Liu's meta-analysis[19], which included 16 studies and 12,116 cases, and the Brazupa study[12] concluded that duration of DM, age, and HbA1c are associated with a significantly increased risk of DPN among individuals with DM. In contrast, body mass index (BMI), triglycerides (TG), and total cholesterol (TC) were not associated with an increased risk of DPN.

The SISPED® platform/application, which incorporates both NSS and NIS for neuropathy assessment and ulcer risk evaluation, includes variables such as duration of disease, presence of comorbidities, random and fasting blood glucose levels, and HbA1c. At the end of each assessment, the application provides recommendations for patient follow-up and automatically sends a final report, written in accessible language, to both the registered healthcare professional and the patient via email. The application also enables the generation and export of reports in spreadsheet format for subsequent analysis. These data were used both for the purposes of this study and for feedback sessions conducted in each FHU where the study took place, involving the entire multidisciplinary team (physicians, nurses, technicians, and CHA) in the patient care process. Individuals classified as high risk were referred to secondary care, in accordance with the application's recommendations. The project was also presented to health managers

in the municipality of Rondonópolis and registered as a university extension project at UFR, with a proposal to expand its implementation to all 64 FHUs in the municipality.

Regarding the application's usability, although the score obtained was classified as fair and below the level considered desirable by SUS®, it is important to emphasize that the SISPED® application was predominantly used by fourth- and fifth-year medical students. These individuals are still in the process of developing competencies in communication, clinical management, and the care of patients with chronic diseases; therefore, they are not yet fully trained or experienced professionals in the follow-up of these users. It is also noteworthy that feedback on SUS® results, as well as the individual responses provided by the students, was shared with the application developers, along with suggestions for potential improvements. It is expected that the present study has contributed to expanding the body of evidence on DPN, as it represents one of the pioneering initiatives in the screening of this condition within PHC in the state of Mato Grosso. The identification of these individuals and the proposal of a structured care pathway are of considerable importance, particularly given that most participants had never previously undergone foot examinations performed by healthcare professionals, despite having a disease duration exceeding ten years in the majority of cases. These findings underscore the need for improved training of healthcare professionals and greater prioritization by health system managers. Preventing the progression to diabetic foot and, consequently, amputations may contribute not only to reducing healthcare costs but also to improving the quality of life of individuals with diabetes mellitus.

CONCLUSION

The use of the SISPED® application enabled the screening and risk stratification of individuals for the development of lower limb ulcers in a population of patients with DM evaluated in PHC by medical students. The prevalence of DPN (31%) was relatively lower than that reported in populations of individuals with DM when compared with studies conducted in referral centers for DM care. Approximately 30% of the studied population was classified as having a moderate to high risk of ulcer development. The usability of the application, as assessed among medical students, was considered fair.

CONFLICT OF INTERESTS

Nothing to declare.

AUTHORS' CONTRIBUTIONS

SMAPL: Conceptualization, Data Curation, Formal Analysis, Writing – Original Draft. MCRP: Conceptualization, Data Curation, Formal Analysis, Writing – Review & Editing.

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