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RESEARCH ARTICLE (ORIGINAL)

Predictive factors for diabetic neuropathy in older people treated in primary care

Fatores preditivos da neuropatia diabética em idosos atendidos na atenção primária

Factores predictivos de la neuropatía diabética en pacientes ancianos en atención primaria

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Abstract

Background: Diabetic neuropathy (DN) is a complication that affects patients with Diabetes Mellitus (DM), a chronic disease with high prevalence among older people.
Objective: To assess the predictive factors for diabetic neuropathy in older people treated in primary care.
Methodology: Cross-sectional study with 111 older people with type 2 DM. A biochemical analysis was performed, and the Beck Depression Inventory, the Visual Numeric Scale, and the Leeds Assessment of Neuropathic Symptoms and Signs Pain Scale were used. The regression analysis was performed using IBM SPSS Statistics, version 20.0.
Results: The prevalence of DN was 29.7%. Pain intensity in the feet and calves was significantly associated with DN ($p = 0.001$). The following factors were significantly associated with DN: glycated hemoglobin ($p < 0.001$), fasting blood sugar level ($p = 0.001$), triglycerides ($p = 0.038$), depression ($p < 0.001$), and a sedentary lifestyle ($p < 0.001$). After logistic regression, high glycated hemoglobin, a sedentary lifestyle, and depression remained associated with DN.
Conclusion: The predictive factors for DN in older people were depression, high glycated hemoglobin, and a sedentary lifestyle.

Keywords: elderly; diabetic neuropathies; primary health care; depression

Resumo

Enquadramento: A neuropatia diabética (ND) é uma complicação que afeta o paciente com diabetes mellitus (DM), doença crónica com elevada prevalência em idosos.
Objetivo: Avaliar os fatores preditivos da neuropatia diabética em idosos atendidos na atenção primária em saúde.
Metodologia: Estudo transversal realizado com 111 idosos com DM tipo 2. Foi realizada análise bioquímica e utilizado Inventário de Depressão de Beck (BDI), Escala Numérica Visual (ENV) e Escala de Dor - *Leeds Assessment of Neuropathic Symptoms and Signs* (LANSS). Análise de regressão foi realizada no IBM SPSS Statistics, versão 20.0.
Resultados: A prevalência de ND foi 29,7%. A intensidade de dor nos pés e gémeos foi significativamente associada à ND ($p = 0,001$). Foram significativamente associados à ND: hemoglobina glicada ($p < 0,001$), glicemia em jejum ($p = 0,001$), triglicerídeos ($p = 0,038$), depressão ($p < 0,001$) e sedentarismo ($p < 0,001$). Após a regressão permaneceram associadas à ND: hemoglobina glicada elevada, sedentarismo e depressão.
Conclusão: Os fatores preditivos para ND em idosos foram depressão, hemoglobina glicada elevada e sedentarismo.

Palavras-chave: idoso; neuropatias diabéticas; atenção primária à saúde; depressão

Resumen

Marco contextual: La neuropatía diabética (ND) es una complicación que afecta a los pacientes con diabetes *mellitus* (DM), una enfermedad crónica con elevada prevalencia en la población anciana.
Objetivo: Evaluar los factores predictivos de la neuropatía diabética en pacientes ancianos en atención primaria.
Metodología: Estudio transversal realizado con e 111 ancianos con DM tipo 2. Se realizaron análisis bioquímicos y se utilizó el Inventario de Depresión de Beck (BDI), la Escala Numérica Visual (ENV) y la Escala del Dolor - Evaluación de Signos y Síntomas Neuropáticos de Leeds (LANSS). El análisis de la regresión se realizó con IBM SPSS Statistics, versión 20.0.
Resultados: La prevalencia de la ND fue del 29,7%. La intensidad del dolor de pies y gemelos se asoció significativamente con la ND ($p = 0,001$). Se asociaron significativamente con la ND: la hemoglobina glucosilada ($p < 0,001$), la glucemia en ayunas ($p = 0,001$), los triglicéridos ($p = 0,038$), la depresión ($p < 0,001$) y el sedentarismo ($p < 0,001$). Tras la regresión, las siguientes variables siguieron asociadas a la ND: hemoglobina glucosilada elevada, sedentarismo y depresión.
Conclusión: Los factores predictivos de la ND en los ancianos fueron la depresión, la hemoglobina glucosilada elevada y el sedentarismo.

Palabras clave: anciano; neuropatías diabéticas; atención primaria de salud; depresión

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Introduction

The International Diabetes Federation (IDF) estimated that the number of people with diabetes mellitus (DM) aged 20 to 79 years in 2017 was 424.9 million, with an estimated increase to 628.6 million people by 2045. Most cases occur in developing countries, leading to about 80% of deaths attributable to the disease. In these countries, the most affected age group was 35-64 years (IDF, 2017).
According to the Brazilian Diabetes Society (*Sociedade Brasileira de Diabetes* – SBD), Brazil is the fourth country worldwide with the highest number of people with DM. The number of people with DM grew 61.8% in 2016. The Federal District had a prevalence rate of 8.6%. According to data from the National Household Sample Survey (*Pesquisa Nacional por Amostra de Domicílios*, PNAD), the prevalence of DM in the elderly population in Brazil is 16.1% (Ministério da Saúde [MS], 2017).
The evolution of DM, especially type 2 DM, leads to complications that may be associated with higher morbidity and mortality, such as retinopathy, nephropathy, neuropathy, coronary disease, cerebrovascular disease, and peripheral arterial disease (Diretrizes da SBD [DSBD], 2019).
Diabetic neuropathy (ND) is a complication that includes a wide variety of signs and symptoms involving sensory, motor, and/or autonomic nerve fibers. It can affect two-thirds of all people with type 2 DM (DSBD, 2019). DN affects approximately 50% of people with diabetes worldwide but it is often diagnosed late, contributing to the development of ulcers, which account for 70% of limb amputations (Santos et al., 2015).
In view of this scenario, this study aimed to identify the main factors associated with DN in older people considering the high prevalence of this complication in people with diabetes. Therefore, it aimed to assess the predictive factors for DN in older people treated in primary care (PC).

Background

In general, DN can range from asymptomatic to physically disabling. Neuropathic symptoms range from severely painful positive symptoms, such as burning pain, stabbing and shooting sensations, uncomfortable temperature sensations, paraesthesia, and hyperesthesia, to mild and negative symptoms, such as decreased painful sensation, fatigue, and numbness, which fluctuate during the day and are extremely uncomfortable and painful at night (IDF, 2017; DS Diretrizes da SBD, 2019).
In this context, patients with DN may present with neuronal injuries, changes in sensory neurons and peripheral nerves, and pain, especially in patients with type 2 DM. Thus, it is important to observe neuropathic deformities in the clinical examination, such as claw toes or hammertoes, with metatarsal bone prominences, followed by high arch (Brinati et al., 2017; DSBD, 2019).
Studies have investigated peripheral neuropathy in older people with type 2 DM (Bai et al., 2017; Brinati et al., 2017; Lima et al., 2018). For example, a study with patients treated in primary care in Brazil found that the most common pain site in patients with diabetes was the feet, with neuropathic characteristics. In addition, patients with DN had a higher number of clinical complaints related to painful sensitivity, especially concerning tingling, "pins and needles", and numbness (Aguiar et al., 2018).
Glycated hemoglobin (HbA1c) is an important marker of metabolic control in these patients as it reflects blood glucose levels over the previous 2 to 3 months. A study found a negative correlation between HbA1c and quality of life as the higher the HbA1c, the lower the patient's quality of life score (Lima et al., 2018).
Furthermore, psychic disorders should be highlighted because chronic neuropathic pain in patients with DM can also lead to the deterioration of factors that influence their quality of life (Lima et al., 2018). The severity of depressive symptoms is higher in patients with DN as moderate to severe depression was observed in patients with DN (Khan et al., 2019).
Considering the available tools and the complexity of the topic, the health team should be trained to identify DN with a focus on prevention and control. An educational patient approach, with regular foot examination and the use of validated scales, can identify complications early and, consequently, prevent DN from worsening.
Moreover, the scarcity of Brazilian studies on DN and the need to increase knowledge about neuropathic characteristics are key aspects for the development of a reflective nursing practice, which is important for the other members of the multidisciplinary team who can deliver comprehensive care and for people who live with this complication of DM. Understanding the factors involved in DN can help guide health professionals' interventions and, consequently, improve the quality of patient care, especially in PC.
Finally, the research instruments on this topic in Brazil are valided. However, they are still scarce given the high incidence of DN in Brazil, thus research should be conducted in primary care settings for an early screening of the evolution of the disease and its complications. Thus, assessment should occur mainly in PC because patients are more likely to be involved in prevention and health promotion interventions at this level of care.

Research question

What are the predictive factors for diabetic neuropathy in older people treated in primary care?

Methodology

A quantitative and cross-sectional study was conducted with 111 older people with diabetes from a basic health unit (*Unidade Básica de Saúde*, UBS) in the Federal District, Brazil. The study population included older people registered in the registration book of the Diabetic Group of the UBS. The following inclusion criteria were applied: being at least 60 years old and having a medical diagno-

sis of type 2 DM for at least 6 months. The exclusion criterion was not being physically and mentally able to communicate verbally and perform the evaluations.

The sample was calculated taking into account a sampling error of 5% and 95% confidence interval, resulting in 115 older people. The sample was randomly selected (lottery), and the file number of each older person registered in the UBS was used for the lottery. Three older persons who did not complete the evaluations were excluded (two individuals did not complete the DN assessment and one did not complete the depression inventory), with the final sample consisting of 111 older people with diabetes. Data were collected from June to August 2019. The randomly selected older people were invited to participate in the study at the group meeting in the UBS. After the invitation, the older people signed the informed consent form (ICF) and were scheduled for data collection at the UBS.

Data were collected in a single day at a private room in the UBS. The evaluators were students and professors of the undergraduate nursing and pharmacy degrees whom the teachers had trained to perform the evaluations. Five steps were followed for data collection.

In the first step, fasting blood samples were obtained from the older people at the UBS by venipuncture, preferably from the antecubital vein. Plasma levels of triglycerides, low-density lipoprotein (LDL), high-density lipoprotein (HDL), total cholesterol, fasting blood glucose, and HbA1c were analyzed at the Testing Laboratory of the University of Brasilia (UnB). The cutoff points for biochemical parameters were as follows: total blood cholesterol ≥190 mmol/L, HDL <40 mmol/L, LDL ≥130 mmol/L, triglycerides ≥150 mmol/L, fasting blood glucose ≥100 mg/dl, and HbA1c (%) ≥7.0 (DSBD, 2019; Faludi et al., 2019).

In the second step, the anthropometric variables of body mass and height were measured. The Body Mass Index (BMI) was calculated as follows: normal (< 27 kg/m^2) and overweight/obesity (≥ 27 kg/m^2; Lipschitz, 1994).

Then, in the third step, a structured instrument was applied through interviews to determine the sociodemographic variables (gender, age, income, marital status, education level, and retirement), self-reported lifestyles (smoking, alcohol, exercise, and sleep habits), clinical variables (duration of DM and number of drugs), and other comorbidities.

In the fourth step, older people completed the Beck Depression Inventory (BDI). This 21-item inventory describes behavioral, cognitive, affective, and somatic manifestations of depression, with a total score ranging from 0 to 63 points as follows: *not depressed* (≤ 9 points) and *depressed* (10-63 points; Gomes-Oliveira et al., 2012).

Finally, the fifth step consists of the assessment of DN using the Leeds Assessment of Neuropathic Symptoms and Signs (LANSS) Pain Scale, which explores qualitative and sensitive aspects. A score of 12 or more in this scale was found to indicate DN in older people. Its total score ranges from 0 to 24 points (Schestatsky et al., 2011). Pain intensity in the feet and calves was assessed using the Visual Numeric Scale (VNS; 0-10 points) and classified as *none* (0), *mild* (1 to 3 points), *moderate* (4 to 6 points), and *severe* (7 to 10 points; Melzack & Katz, 1994).

Data were analyzed using IBM SPSS Statistics software, version 20.0. Initially, a descriptive analysis was performed using absolute and relative frequencies. The chi-square test was used to test for differences in proportions. A binary logistic regression model was developed to identify predictive variables for DN in older people. The stepwise method was adopted to enter the variables into the model. Independent variables were selected based on sample size and a minimum significance level of $p < 0.20$. Odds ratio (OR) was calculated for a significance level of 5% and a 95% confidence interval to measure the strength of association between the independent variables and DN. The Hosmer-Lemeshow test was used to measure the model's goodness-of-fit.

The Ethics Committee of the Health Department of the Federal District (SES/DF) approved this study (Opinion no. 1.355.211 and CAAE 50367215.5.0000.5553). It is part of the project *Abordagem das condições crônicas não transmissíveis na atenção primária* (Approach to chronic non-communicable diseases in primary health care) of the research group Health, Care, and Aging of the University of Brasília. All procedures followed the principles of the National Research Council, the legislation in force in Brazil (Resolution No. 46/2012), and the Declaration of Helsinki.

Results

The prevalence of DN was 29.7%. Most older people were women aged 65 to 69 years, with up to 5 years of schooling, a monthly income of less than or equal to one minimum wage, married, and retired (Table 1).

Table 1

Analysis of the sociodemographic factors according to diabetic neuropathy

		LANSS					
		With neuropathy (*n* = 33)		Without neuropathy (*n* = 78)			
		N	%	N	%	OR (95% CI)	*p*-value
Gender	Female	23	69.7	62	79.5	0.70 (0.38-1.28)	0.192
	Male	10	30.3	16	20.5	1	-
Age (years)	60 to 64	14	42.4	21	26.9	2.07 (0.75-5.69)	0.153
	65 to 69	10	30.3	29	37.2	1.07 (0.37-3.03)	0.894
	≥70	9	27.3	28	35.9	1	-
Education level	Illiterate	5	15.2	9	11.5	1	-
	Basic education	21	63.6	55	70.5	0.68 (0.20-2.28)	0.539
	Secondary education	7	21.2	14	17.9	0.90 (0.21-3.72)	0.884
Monthly income	≤1 MW	22	66.7	41	52.6	1.52 (0.82-2.82)	0.170
	≥2 MW	11	33.3	37	47.4	1	
Marital status	Single	6	18.2	12	15.4	0.86 (0.33-2.23)	0.768
	Married	17	51.5	33	42.3	0.88 (0.23-2.90)	0.763
	Divorced	5	15.2	8	10.3	1	-
	Widowed	5	15.2	25	32.1	0.32 (0.07-1.39)	0.120
Retired	yes	23	69.7	56	71.8	0.93 (0.50-1.72)	0.497
	no	10	30.3	22	28.2	1	

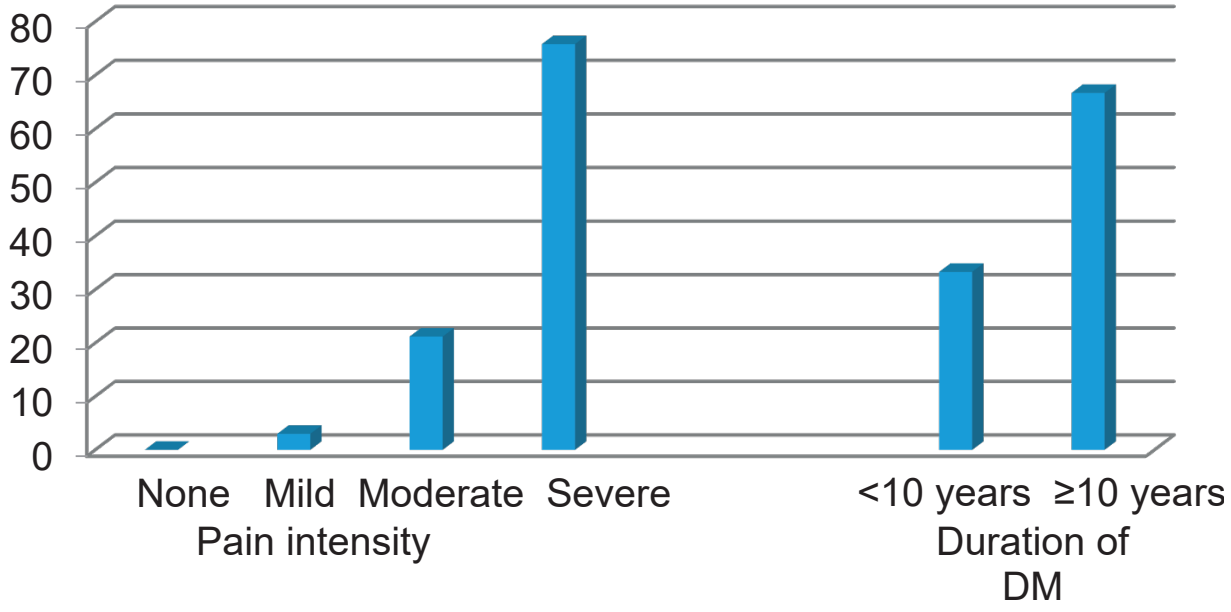
Note. LANSS = Leeds Assessment of Neuropathic Symptoms and Signs; *OR* = odds ratio; CI = confidence interval; MW = minimum wage - R$954,00.

Figure 1 shows pain intensity and duration of DM in patients with DN. The presence of pain in the feet and calves was reported by 82.9% of the older adults, with 73.2% reporting it as severe pain. Pain intensity in the feet and calves was significantly associated with DN in older people (p = 0.001). Older people with severe pain in the feet and calves had a 2.53 times higher risk of developing DN (95% CI = 1.85-6.96).

The time of diagnosis of DM was associated with DN (p = 0.026) because those participants who had been diagnosed with the disease for more than 10 years had a 2.58 times higher risk of developing DN (95% CI =1.10-6.06).

Figure 1

Prevalence of pain intensity in the feet and/or calves and duration of DM among older people with diabetic neuropathy



The analysis of the biochemical factors, clinical factors, and lifestyles of older people with DM showed that 46.8% had an HbA1c ≥7%, 77.5% had fasting glucose levels ≥100mmol/L, 58.5% had triglycerides levels ≥150mmol/L, 42.3% had total cholesterol levels ≥190mmol/L, 26.1% had LDL levels ≥130mmol/L, 21.6% had HDL levels below 40mmol/L, 73.0% had a BMI ≥27, 60.4% had depression, 8.1% had smoking habits, 6.3% had drinking habits, 40.5% had sedentary lifestyles, 42.3% had sleep problems, 84.7% had high blood pressure, and 63.0% took more than four drugs per day (Table 2).

Among these factors, glycated hemoglobin ≥7.0% (OR = 1.86; $p < 0.001$), fasting blood glucose ≥ 100 mmol/L (*OR* = 1.52; $p = 0.001$), triglycerides ≥ 150 mmol/L (OR = 1.88; $p = 0.038$), depression (OR = 6.56; $p < 0.001$), and a sedentary lifestyle (OR = 1.85; $p < 0.001$) increased the risk of DN (Table 2).

Table 2

Associations between chemical factors, clinical factors, lifestyles, and diabetic neuropathy

		LANSS					
		With neuropathy (*n* = 33)		Without neuropathy (*n* = 78)			
		n	%	*n*	%	*OR* (95% CI)	*p*-value***
HbA1c (%)	< 7.0	6	18.2	53	67.9	1	
	≥7.0	27	81.8	25	32.1	1.86 (1.39-2.51)	<0.001
Fasting blood glucose (mmol/L)	< 100	1	3.0	24	30.8	1	
	≥ 100	32	97.0	54	69.2	1.52 (1.27-1.83)	0.001
Triglycerides (mmol/L)	< 150	9	27.3	37	47.4	1	
	≥ 150	24	72.7	41	52.6	1.88 (1.06-3.67)	0.038
Total cholesterol (mmol/L)	< 190	22	66.7	42	53.8	1.46 (0.79-2.72)	0.149
	≥190	11	33.3	36	46.2	1	
LDL (mmol/L)	< 130	26	78.8	56	71.8	1.31 (0.64-2.69)	0.302
	≥ 130	7	21.2	22	28.2	1	
HDL (mmol/L)	< 40	7	21.2	17	21.8	1	
	≥40	26	78.8	61	78.2	0.97 (0.48-1.96)	0.580
BMI* (kg/m^2)	< 27	6	18.2	24	30.8	1	
	≥27	27	81.8	54	69.2	1.20 (0.94-1.52)	0.128
Depression**	Yes	30	90.9	37	47.4	6.56 (2.13-20.21)	0.000
	No	3	9.1	41	52.6	1	
Smoking	Yes	2	6.1	7	9.0	1	
	No	31	93.9	71	91.0	0.73 (0.20-2.57)	0.465
Alcohol	Yes	1	3.0	6	7.7	1	
	No	32	97.0	72	92.3	0.46 (0.07-2.91)	0.327
Sedentary lifestyle	Yes	24	72.7	21	26.9	1.85 (1.33-2.56)	<0.001
	No	9	27.3	57	73.1	1	
Sleep problems	Yes	17	51.5	30	38.5	0.69 (0.39-1.22)	0.144
	No	16	48.5	48	61.5	1	
High blood pressure	Yes	29	87.9	65	83.3	1.31 (0.52-3.25)	0.385
	No	4	12.1	13	16.7	1	
Number of drugs (per day)	< 4	12	36.4	29	37.2	1	
	≥4	21	63.6	49	62.8	0.97 (0.53-1.76)	0.556

Note. LANSS = Leeds Assessment of Neuropathic Symptoms and Signs; *OR* = Odds ratio; HbA1c = Glycated hemoglobin; LDL = Low-density lipoprotein; HDL = High-density lipoprotein; * BMI = Body Mass Index; ** BDI = Beck Depression Inventory; *** Chi-square test.

Six variables were used in the binary logistic regression analysis to determine the association with ND, based on sample size. Thus, the following variables were included in the model: glycated hemoglobin, duration of DM, severe pain in the feet, triglycerides, depression, and sedentary lifestyle. The following variables remained associated with DN, significantly increasing its risk: depression, high glycated hemoglobin, and sedentary lifestyle (Table 3).

Table 3

Analysis of the predictive factors for neuropathy in older people with diabetes: binary logistic regression

	p-value	*OR*	95% CI	
			Lower	Upper
HbA1c ≥7.0 %	0.001	9.948	2.714	36.460
Duration of DM ≥ 10 years	0.998	1.002	0.263	3.821
Triglycerides ≥ 150 mmol/L	0.076	3.256	0.885	11.981
Intense pain in the feet and/or calves	0.057	3.682	0.964	14.071
Sedentary lifestyle	0.002	7.904	2.190	28.524
Depression	0.001	14.812	3.105	70.644

Note. OR = Odds ratio; CI = Confidence interval; HbA1c = glycated hemoglobin; DM = diabetes mellitus. Goodness-of-fit (Hosmer-Lemeshow test): $p = 0.811$.

Discussion

In this study, the prevalence of DN in older people corresponded to approximately one-third of the sample, which is consistent with the results found by Brinati et al. (2017). Other studies found lower values (Garoushi et al., 2019; Mejias & Ramphul, 2018). The differences in the prevalence of DN across studies may be associated with the diagnostic method and the duration of diabetes given that older people with diabetes for a longer period of time tend to have DN and some diagnostic methods may diagnose a higher prevalence.

Concerning older people's sociodemographic profile, this study revealed that the majority of participants were women, married, aged 60-64 years. This profile aligns with the national (Aguiar et al., 2018; Lima et al., 2018) and international reality (Bai et al., 2017; Khan et al., 2019). Sociodemographic variables are important due to the patients' profile and their ability to understand and adopt measures to care for DN. People with a low education level may have difficulties in performing care activities and recognizing signs of complications.

Concerning the participants' biochemical data, the variables glycated hemoglobin, triglycerides, and blood glucose were associated with DN. These variables have been associated with DN both in national (Gomes et al., 2018) and international studies (Bai et al., 2017; D'Amato et al., 2016; Garoushi et al., 2019; Khan et al., 2019). Together with these biochemical changes, an inadequate glycemic profile has been positively correlated with DN (DSBD, 2019).

The changes related to a poor metabolic control of DM and the dyslipidemia-associated alterations contribute to the inflammatory process and may influence the development of DN and the worsening of neuropathic pain. According to the SBD, blood glucose control can also improve the lipid profile, particularly in patients with high triglyceride levels. In addition, the risk for cardiovascular disease is two to four times higher in patients with type 2 DM than in non-diabetic patients, with dyslipidemia being one of the most important risk factors (DSBD, 2019).

Controlling these biochemical findings is very important because our sample had a high BMI. Maintaining a healthy weight and overall health are necessary for controlling DN and its complications.

Another important characteristic of DN in this study was the presence of pain in the feet and/or calves in almost all participants, with almost half of them describing it as severe pain. Pain in the lower limbs is one of the characteristics of DN and has been reinforced by the use of the LANSS scale, which also characterizes neuropathy. Pain is described as a complex and subjective symptom, gradually leading to physical, psychological, and social limitations (DSBD, 2019).

In this study, the older people with severe pain had a higher risk of developing DN. Another study also found the presence of severe pain in individuals with DN (Lima et al., 2018). It should be noted that neuropathic pain has different neurophysiological mechanisms directly related to a longer duration of DM because patients remain in a state of persistent inflammation, which triggers permanent lesions in the sensory system (Pop-Busui et al., 2016; DSBD, 2019).

After the logistic regression analysis, the following main predictive factors for DN were identified: depression, glycated hemoglobin, and a sedentary lifestyle. The variable associated with a higher risk of DN was the presence of depression. The literature has demonstrated that depression is a condition present in DM, being twice as prevalent in women and three times in patients with diabetes (Lima et al., 2018). An international study has found that the majority of the 42.4% of patients with DN had depression (Bai et al., 2017). Other international studies have also found a high prevalence of depression in patients with DN (D'Amato et al., 2016; Khan et al., 2019).

A study conducted in Brazil has identified the main predictors for depressive symptoms. Of 121 participants, 53.8% had DN, 59.5% reported severe pain, and 66.9% had depression. The risk factors for depression were a poor quality of life, the presence of severe pain, obesity, and poor glycemic control (Lima et al., 2018).

It should be noted that individuals with depression have greater difficulties in adapting to and following a thera-

peutic regimen because patients with DM usually take several medications to treat the disease. In addition, older people can have DM and other conditions for a longer period of time, which can promote a depressive mood (Khan et al., 2019; DSBD, 2019).

Another predictor for DN was altered glycated hemoglobin. Among the biochemical factors analyzed in this study, the majority of older people had poor metabolic control. After adjustment of the regression analysis, only HbA1c remained associated with a higher risk for DN. The high number of older people with HbA1c ≥7.0% found in this study can be explained by inadequate lifestyles, late diagnosis, ineffective treatment, and even lack of adherence to treatment, which was observed in this sample of older people. A study conducted in a Family Health Unit of Belém in Pará, Brazil, found an average HbA1c level of 9.92% among 120 participants (Gomes et al., 2018).

International studies have also found higher HbA1c levels in patients with DN (Bai et al., 2017; D'Amato et al., 2016; Lima et al., 2018). It should be noted that HbA1c reflects the concentration of blood glucose levels between 2 and 3 months. This finding reveals that patients with DN in this study have poor glycemic control, not having an effective treatment for DM. The poor glycemic control reflected in the HbA1c levels is directly related to inflammatory processes, especially in neural ganglia (DSBD, 2019).

Finally, a sedentary lifestyle was another risk factor for DN in older people found in this study. The analysis of lifestyles and eating habits shows that the BMI curve of patients with DM is related to a sedentary life with a predisposition to obesity. Obesity is considered one of the main risk factors for type 2 DM. It is estimated that 60-90% of type 2 DM patients are obese, and the incidence is higher after the age of 40 (Diretrizes da SBD, 2019).

It is important to highlight that exercise increases the action of insulin through short-term effects, mainly through insulin-dependent glucose transport, and raises energy expenditure, which helps to reverse obesity-associated type 2 DM. Physical activity regulates and produces health benefits while improving cardiovascular fitness, including enhanced glycemic control, insulin signaling, and blood lipids, as well as reduced low-grade inflammation, improved vascular function, and weight loss (Kirwan et al., 2017).

If DN is confirmed by clinical examination, bodyweight exercises should be avoided. Therefore, exercises such as swimming/water aerobics, cycling, and arm/chair exercises are recommended as long as they do not require body weight support, such as prolonged walking (Diretrizes da SBD, 2019).

Patients diagnosed with DM face many challenges in their everyday lives, particularly the changes in their lifestyles, starting with their diet. Patients must impose dietary restrictions, pay attention to the number of calories in their food, take medications, self-monitor their blood glucose level, which involves pricking their own finger, and pay attention to possible injuries because DM delays healing (Diretrizes da SBD, 2019).

A limitation of this study was its cross-sectional design, which does not allow establishing cause and effect. Another limitation was that the variable sedentary lifestyle was self-reported. Despite this, the study brings relevant contributions to nursing because its results can improve the quality of primary care while enabling healthcare professionals to be more effective.

Conclusion

Many older people complained about severe pain in the feet and calves, which was significantly associated with DN because it increased the risk of developing DN. The predictive factors for DN were high glycated hemoglobin, a sedentary lifestyle, and depression.

In this context, it is important to conduct a comprehensive foot examination and for health professionals, especially nurses, to involve patients in educational activities aimed at promoting self-care and early detection of DN. Further studies should be conducted on this topic using longitudinal designs to provide evidence on factors related to DN in older people that can be used to plan early and effective interventions for preventing DN in primary care settings.

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