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Original Research Article

Prevalence and associated factors of peripheral neuropathy in type 2 diabetic patients in Antananarivo: a three-year cross-sectional study

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ABSTRACT

Background: Diabetic peripheral neuropathy (DPN) is common, causing functional disability and impaired quality of life for patients. The aims of this study were to determine the prevalence of DPN and its associated factors in type 2 diabetics seen at the Soavinandriana Hospital Center.
Methods: This was a descriptive and analytical cross-sectional study, conducted on a 3-years period. The diagnosis of DPN was made based on a DN4 questionnaire score ≥4 and/or impaired sensitivity to 10 monofilament and/or a reduction or absence of the Achilles reflex.
Results: Among the 289 DT2 patients, the prevalence of DPN was 28.7%. Risk factors for DPN were age 60-69 years [OR=1.83 (1.06-3.19), p=0.0139], dyslipidemia [OR=3.31 (1.47-3.49), p=0.0009], microalbuminuria [OR=6.98 (3.85-12.9), p<0.0001], diabetes duration ≥10 years [OR=2.80 (1.42-5.52), p=0.0011], glycated hemoglobin level ≥7% [OR=2.25 (1.03-5.85), p=0.0287], presence of nephropathy [OR=13.2 (6.82-26.2), p<0.0001], retinopathy [OR=2.71 (1.42-5.15), p=0.0009], carotid atherosclerosis [OR=2.73 (1.57-4.79), p=0.0001], lower limb arteriopathy [OR=2.27 (1.21-4.23), p=0.0047] and ischemic heart disease [OR=3.41 (1.72-6.82), p=0.0001].
Conclusions: The frequency of DPN was 28.7%. Associated factors were advanced age, the presence of other cardiovascular risk factors, a long duration of diabetes and its poor control, and the presence of other degenerative diabetes complications. Better control of diabetes and associated cardiovascular risk factors with multidisciplinary care are essentials to avoid or limit their occurrence.

Keywords: Degenerative complications, Diabetic peripheral neuropathies, Risk factors, Type 2 diabetes

INTRODUCTION

Diabetes mellitus is one of the most widespread chronic non-communicable diseases in the world. According to the International Diabetes Federation (IDF), in 2024, 588.7 million people worldwide suffered from it, and this number is expected to reach 852.5 million by 2050.[1]

It refers to "a group of metabolic diseases characterized by hyperglycemia resulting from defects in the secretion or action of insulin, or both combined" causing damage to many body's organs, leading to disabling and life-threatening health complications such as cardiovascular diseases (CVD), nerve damage (neuropathy), kidney damage (nephropathy), lower-limb amputation, and eye disease (retinopathy).[1]

Among its nervous complications are diabetic peripheral neuropathies (DPN). DPN are defined by a peripheral nerve dysfunction in a diabetic patient after other etiologies have been excluded. Distal symmetric polyneuropathy (DSP) is their most common clinical presentation.[2]

Their pathogenesis is multifactorial, involving complex interactions between glycemic imbalance, the duration of diabetes, age-related neuronal attrition, and other factors such as blood pressure, blood lipid levels, and weight. These abnormalities lead to ischemic events and metabolic disturbances in the nerves.[3,4]

Worldwide, diabetic neuropathy is the most frequent cause of neuropathies, with an estimated prevalence of 6% to 51% in diabetic adults.[3,5] They sometimes lead to debilitating pain, lower limb amputations, and physical disability, consequently reducing quality of life.[6]

Very few studies have been conducted on this subject in Madagascar. One study carried out in 2023 at the endocrinology department of the Joseph Raseta Befelatanana University Hospital found a prevalence of 36% of DPN among type 2 diabetics consulted but this study did not specifically look at the factors associated with the presence of DPN.[7]

The aims of this study were therefore to determine the prevalence of DPN, and to identify the factors associated with its presence in a population of type 2 diabetics in order to improve their management.

METHODS

This was a descriptive and analytical cross-sectional study exhaustively including all type 2 diabetic patients hospitalized at the Soavinandriana Hospital Center (CENHOSOA) from January 1, 2021 to December 31, 2023 (36 months) in whom a clinical search for diabetic peripheral neuropathy was carried out.

Diabetes was diagnosed based on patient self-reporting or the use of antidiabetic medications. Newly diagnosed diabetes was diagnosed based on the American Diabetes Association (ADA) diagnostic criteria. Type 2 diabetes was suspected if the patient was over 35 years old at the time of diagnosis and/or overweight or obese and/or had a family history of type 2 diabetes, and/or had other cardiovascular risk factors, in the absence of obvious secondary causes of diabetes.[8]

The diagnosis of DPN was purely clinical. It was made in the presence of symmetrical distal sensory symptoms beginning in the lower limbs assessed using the neuropathic pain 4 questionnaire (DN4) with a score ≥4/10 and/or altered sensation of the foot on examination with a 10 gm monofilament and/or a decrease or absence of the Achilles reflex.[9]

Patients with a pathology or situation likely to give rise to neuropathy were excluded, including chronic alcoholism, spinal cord compression, neurotoxic drugs such as chemotherapy, hypothyroidism and human immunodeficiency virus (HIV) infection as well as those with a neurological or mental disorder that makes the answers to the DN4 questionnaire uninterpretable.[8]

The study population was divided into two groups: those with DPN and those without DPN.

The variables studied were: the presence or absence of DPN; socio-demographic characteristics of the patients including gender and age divided into (30-39 years), (40-49 years), (50-59 years), (60-69 years), ≥70 years; cardiovascular risk factors associated with diabetes include high blood pressure (HBP), active smoking, overweight or obesity, dyslipidemia, and pathological 24-hour microalbuminuria; and characteristics of diabetes including its duration of evolution, previous antidiabetic treatments [oral antidiabetics (OADs), insulin], the control of diabetes (well controlled if HbA1c<7%, poorly controlled if HbA1c≥7%), other chronic degenerative complications of diabetes [retinopathy, nephropathy, ischemic stroke (IS), carotid atherosclerosis (CA), coronary artery disease (CAD), lower limb arteriopathy (LLA) or history of amputation or vascular surgery of the lower limbs].

Clinical and paraclinical data

High blood pressure was confirmed by a blood pressure ≥140/90 mmHg on at least 2 repeated measurements or a self-declaration of taking antihypertensive medication by the patient.[10]

Dyslipidemia was defined as a low plasma level density lipoprotein cholesterol (LDLc) above the target for the corresponding cardiovascular risk of the patient according to the European Society of Cardiology (ESC) 2019 criteria or taking a lipid-lowering drug.[11]

Microalbuminuria is defined as urinary albumin excretion of between 30 mg and 300 mg in urine collected over 24 hours, or 30 mg/gm or 3 mg/mmol in urine samples.[12]

Patients were considered overweight or obese if their body mass index (BMI) was ≥25 kg/m^2 or ≥30 kg/m^2 respectively.

The presence of other degenerative complications of diabetes was determined on the basis of specific anamnestic, clinical and paraclinical criteria for each complication.[8]

The monofilament test was performed using a 10, 5.07-gauge Nylon® monofilament applied perpendi-cularly to three plantar sites on both feet (opposite the pulp of the first toe and the heads of the first and fifth metatarsals) randomly for one and a half seconds. The application was to be repeated three times on the same site, one of which was a sham application. If two out of three perception errors occurred at a given site, the patient was considered at risk of asymptomatic ulceration due to loss of protective sensitivity.[13]

Data were collected from patient records using a pre-established and pre-tested data collection form. They were

then transcribed into Microsoft Excel and subsequently imported and analyzed using Epi Info™ version 3.5.4®. The statistical analysis consisted of describing and comparing the distribution of patients according to each variable studied in the two groups in order to identify the specific characteristics of patients with DPN.

The statistical tests used for the comparative analysis were the Chi-square test for qualitative variables and the student's test for quantitative variables. The odds ratio (OR) was used as an association measure. It was retained as significant when the value 1 was not included in the 95% confidence interval (95% CI). A p value ≤0.05 was considered statistically significant.

This work was carried out after obtaining the agreement of the director of the establishment, and the head of department. Oral information was provided to each subject participating in the study. The investigations were undertaken only after each participant had signed a free and informed consent form. The data collected were anonymized before being processed by computer.

RESULTS

During the study period, 303 patients were included and 14 were excluded. Finally, 289 patients were included in the study, of whom 83 (28.71%) had developed DPN according to the diagnostic criteria for this complication.

The general characteristics of the study population were summarized in Table 1.

The socio-demographic characteristics of patients according to the presence or absence of DPN were reported in Table 2. Gender was not associated with DPN. The mean age of patients with DPN was 65.5±8.2 years versus 61.9±10.4 years for those without DPN, and this difference was statistically significant (p=0.0023). The 60-69 age group was a factor associated with DPN [OR=1.83 (1.06-3.19), p=0.0139].

Table 1: General characteristics of the study population (n=289).

Variables		Number (n=289)	Proportion (%)
Gender	Male	149	51.6
	Female	140	48.4
Age (years)	30-39	10	3.5
	40-49	18	6.2
	50-59	63	21.8
	60-69	136	47.1
	≥70	62	21.4
Dyslipidemia		227	78.5
HBP		204	70.6
Microalbuminuria		89	30.8
Smoking		76	26.3
Overweight or obesity		35	12.1
Newly diagnosed diabetes		60	20.8
Diabetes duration (years)	1-4	94	32.5
	5-9	85	29.4
	≥10	50	17.3
Antidiabetic OAD		140	48.4
Antidiabetic insulin		67	23.2
No antidiabetic treatment		42	14.5
Antidiabetic OAD + insulin		40	13.9
HbA1c ≥ 7%		241	83.4
HbA1c <7%		48	16.8
Microangiopathies		111	38.4
Nephropathy		73	25.3
Retinopathy		58	20.1
Macroangiopathies		161	55.7
CA		120	41.5
CAD		63	21.8
IS		58	20.1
LLA		48	16.6

CA: carotid atherosclerosis; CAD: Coronary artery desease; HbA1c: glycated hemoglobin; IS: ischemic stroke; LLA: lower limb arteriopathy; OAD: oral antidiabetic drug.

Table 2: Socio-demographic characteristics associated with the presence of DPN (n=289).

Variables		DPN		OR (95 % CI)	P value
		Present (n=83)	Absent (n=206)		
Gender (%)	Female	43 (51.8)	97 (47.1)	1 (Reference)	
	Male	40 (48.2)	109 (52.9)	0.82 (0.48-1.42)	0.2754
Average age, years (±SD)		65.5 (±8.2)	61.9 (±10.4)		0.0023*
Age (%)	30-39	0 (0)	10 (4.9)	1 (Reference)	
	40-49	0 (0)	18 (8.7)		0.0018*
	50-59	17 (20.5)	46 (22.3)	0.89 (0.44-1.73)	0.4308
	60-69	48 (57.8)	88 (42.7)	1.83 (1.06-3.19)	0.0139*
	≥70	18 (21.7)	44 (21.4)	1.02 (0.51-1.95)	0.5334

CI: confidence interval; DPN: diabetic peripheral neuropathy; ND: not defined; OR: odds ratio; *p value <0.05; SD: standard deviation.

Table 3: Other cardiovascular risk factors associated with the presence of DPN (n=289).

Variables	DPN		OR (95% CI)	P value
	Present (n=83)	Absent (n=206)		
Dyslipidemia (%)	75 (90.4)	152 (73.8)	3.31 (1.47-3.49)	0.0009*
HBP (%)	62 (74.7)	142 (68.9)	1.33 (0.73-2.49)	0.2038
Microalbuminuria (%)	51 (61.4)	38 (18.4)	6.98 (3.85-12.9)	<0.0001*
Smoking, (%)	27 (32.5)	49 (23.8)	1.54 (0.84-2.79)	0.0849
Overweight or obesity (%)	13 (15.7)	22 (10.7)	1.55 (0.67-3.43)	0.1642

CI: Confidence interval; DPN: Diabetic peripheral neuropathy; HBP: High blood pressure; OR: Odds Ratio; *p value <0.05.

Table 4: Diabetes characteristics associated with the presence of DPN (n=289).

Variables	DPN		OR (95% CI)	P value
	Present (n=83)	Absent (n=206)		
Average duration, year (±SD)	7.63 (±6.47)	4.46 (±4.79)	---	<0.0001*
Newly diagnosed diabetes (%)	16 (19.3)	44 (21.4)	1 (Reference)	
1-4 years (%)	17 (20.5)	77 (37.4)	0.43 (0.22-0.81)	0.0035*
5-9 years (%)	28 (33.7)	57 (27.7)	1.33 (0.74-2.37)	0.1886
≥10 years (%)	24 (28.9)	26 (12.6)	2.80 (1.42-5.52)	0.0011*
Antidiabetic OAD (%)	44 (53.0)	96 (46.6)	1.29 (0.75-2.22)	0.1958
Insulin (%)	21 (25.3)	46 (22.3)	1.18 (0.61-2.21)	0.3456
No antidiabetic (%)	4 (4.8)	24 (11.7)	0.39 (0.09-1.17)	0.0541
OAD + insulin (%)	8 (9.6)	32 (15.5)	0.58 (0.22-1.36)	0.1289
HbA1c <7% (%)	8 (9.6)	40 (19.4)	1 (Reference)	
HbA1c ≥7% (%)	75 (90.4)	166 (80.6)	2.25 (1.03-5.85)	0.0287*
Microangiopathies (%)	78 (94.0)	33 (16.0)	79.8 (29.7-272)	<0.0001*
Nephropathy (%)	51 (61.4)	22 (10.7)	13.2 (6.82-26.2)	<0.0001*
Retinopathy (%)	27 (32.5)	31 (15.0)	2.71 (1.42-5.15)	0.0009*
Macroangiopathies (%)	66 (79.5)	95 (46.1)	4.51 (2.42-8.79)	<0.0001*
CA (%)	49 (59.0)	71 (34.5)	2.73 (1.57-4.79)	0.0001*
LLA (%)	27 (32.5)	36 (17.5)	2.27 (1.21-4.23)	0.0047*
IS (%)	15 (18.1)	43 (20.9)	0.83 (0.40-1.66)	0.3582
CAD (%)	25 (30.1)	23 (11.2)	3.41 (1.72-6.82)	0.0001*

CA: carotid atherosclerosis; CAD: coronary artery disease; CI: confidence interval; DPN: diabetic peripheral neuropathy; HbA1c: glycated hemoglobin; IS: ischemic stroke; LLA: lower limb arteriopathy; OAD: oral antidiabetic drug; OR: Odds ratio; *p value <0.05.

Other cardiovascular risk factors associated with the presence of DPN were dyslipidemia [OR=3.31 (1.47-3.49), p=0.0009] and the presence of pathological microalbuminuria [OR=6.98 (3.85-12.9), p<0.0001] as shown in Table 3.

The characteristics of diabetes associated with the presence of DPN were represented in Table 4. In this case, a duration of diabetes ≥10 years as well as poorly controlled diabetes (HbA1c≥7%) were associated with DPN with OR=2.80 (1.42-5.52), p=0.0011 and OR=2.25

(1.03-5.85), p=0.028 respectively. Likewise for the presence of microangiopathic complications [OR=79.8 (29.7-272), p<0.0001], namely diabetic nephropathy [OR = 13.2 (6.82-26.2), p<0.0001] and diabetic retinopathy (OR=2.71 (1.42-5.15), p=0.0009], as well as macroangiopathic complications [OR=4.51 (2.42-8.79), p<0.0001], including carotid atherosclerosis [OR=2.73 (1.57-4.79), p=0.0001], lower limb arteriopathy [OR=2.27 (1.21-4.23), p=0.0047], and coronary artery disease [OR =3.41) (1.72-6.82), p=0.0001].

DISCUSSION

In the present study, the hospital prevalence of DPN was 28.71%. DPN prevalence varies between studies. This prevalence was similar to those reported by Kisozi et al in Uganda (29.4%) and Ponirakis et al in Qatar (23.9%).[14,15] However, it was lower than that reported locally in the endocrinology department of Joseph Raseta University Hospital, Befelatanana by Raherison et al (36%).[7] Agyekum's team in Ghana reported in their study that 20.6% of patients presented with confirmed DPN based on abnormal perception of the vibration test and 35.6% with DPN based on clinical symptoms.[16] Using the Michigan Neuropathy Screening Instrument (MNSI) score to diagnose DPN, Khawaja and his team had found a prevalence of 39.5% in Jordan.[17] Thus, the prevalence of DPN is influenced by the difference in study populations from one region to another and from one country to another, and especially by the diagnostic criteria.

In the present study, patients with DPN were significantly older than those without DPN, and the 60-69-year age group was significantly associated with DPN. Similarly, Ponirakis et al in Qatar, Negussie et al in Ethiopia and Amour et al in Tanzania have all objectively shown that age >60 years was an independent risk factor for DPN.[15,18,19]

Indeed, advanced age increases stress oxidative activity, promotes the stimulation of counter-regulatory signaling pathways and mitochondrial dysfunction. This increases the risk of inflammation and peripheral nerve damage, paving the way for neuroperfusion injury (DPN).[20-22]

In the present study, dyslipidemia and microalbuminuria were identified as risk factors for diabetic neuropathy. Other authors have also reported the same finding for dyslipidemia.[15,17] Indeed, according to the literature, dyslipidemia is implicated in the pathogenesis of diabetic neuropathy through a dual mechanism: direct via neuronal damage caused by the action of oxidized insulin low-density excess lipoprotein (LDL-Ox) during dyslipidemia and indirectly through nerve ischemia secondary to the development of atherosclerosis in the vasa nervorum.[23,24] Microalbuminuria and macroalbuminuria have also been reported as being associated with the presence of DPN by Pai's team in Taiwan.[25] This association supports the theory of a vascular etiology of diabetic peripheral neuropathy, which it shares with diabetic nephropathy, the first sign of which is the presence of microalbuminuria. Furthermore, microalbuminuria is an important biochemical marker for assessing risk factors for microvascular complications in type 2 diabetes.[26] Contrary to the results of other studies, ours did not find a significant association between HBP and the presence of DPN.[27,28] In any case, optimizing blood pressure control is always recommended to prevent or delay the onset of DPN, given that HBP induces endothelial dysfunction and damages the vasa nervorum, leading to the development of DPN.[29] Similarly, it is associated with chronic low-grade inflammation, which is detrimental to nerve function and the progression of DPN.[30]

The mean duration of diabetes in our patients with DPN was significantly longer than in those without DPN (7.63 years versus 4.46 years), and a duration ≥10 years was a risk factor for DPN. The same trend was also observed by Jaiswal et al. in their study (8.6 years versus 7.6 years).[31] Jember et al also found that duration of diabetes ≥10 years was a risk factor for DPN.[32] For Mekuria Negussie et al, duration of diabetes >5 years already promoted the occurrence of DPN.[18] Indeed, a long duration of diabetes corresponds to prolonged exposure to chronic hyperglycemia which activates several metabolic pathways, causing oxidative stress in diabetics neurons and leading to nerve damage and neuronal ischemia.[33,34] Hence the importance of regular screening for PND, particularly in subjects whose diabetes has been progressing for a long time.

Contrary to the results of other authors, we did not find an association between previous antidiabetic drugs used by patients, including insulin, and the existence of DPN.[35] In fact, insulin therapy is more of an indicator of poorly controlled diabetes than a factor of complications. Moreover, while in these other countries, insulin therapy is only initiated when the combination of several oral antidiabetic agents fails, in Madagascar, it is prescribed fairly rapidly because the combination of several antidiabetic drugs is too expensive and insulin therapy seems cheaper. It should be noted that the insulin most widely used in Madagascar is still regular insulin.[7]

Poorly controlled diabetes, as evidenced by an HbA1c level ≥7%, increased the risk of DPN by 2.25 in this study. For Kuate-Tegueu et al in Cameroon, an HbA1c level >7.5% increased this risk by 9.2.[36] Strict long-term glycemic control would therefore be one of the pillars of preventive approaches to DPN.[37]

The association of DPN with other degenerative complications of diabetes (microangiopathies including nephropathy and retinopathy, and macroangiopathies including carotid atherosclerosis, lower limb arteriopathy, and coronary artery disease) has also been observed by other authors. Khawaja et al found a significant relationship between DPN and cardiovascular complications, as well as diabetic retinopathy, in their study.[17] Kuate-Tegueu et al found that the presence of

DPN was associated with chronic kidney disease.[36] In the study by Katulanda et al, the presence of retinopathy predicted the presence of DPN.[38] Indeed, microangiopathy and macroangiopathy share a common pathophysiology, revealing endothelial dysfunction, chronic inflammation, and a prothrombotic state.[39] Thus, the discovery of DPN, the positive diagnosis of which is easily established clinically, should lead to a systematic search for other chronic degenerative complications of diabetes, both microvascular and macrovascular. Their management must be early, appropriate, and multidisciplinary to limit diabetes-related morbidity and mortality.

The study was limited by its retrospective single-center nature, the use of the DN4 score limited to the diagnosis of painful DPN, simple and easy instead of the MNSI score, more complicated but allowing the diagnosis of DPN regardless of its form, as well as the non-performance of nerve biopsy or nerve conduction study.

CONCLUSION

In conclusion, the frequency of DPN is high among Malagasy patients with type 2 diabetes. It is associated with advanced age, the presence of other cardiovascular risk factors, a long duration of diabetes and poor glycemic control, as well as the presence of other chronic vascular degenerative complications of diabetes.

Screening, prevention, and management must be early, appropriate, and multidisciplinary, particularly in individuals with these risk factors. Investigation for other chronic degenerative complications of diabetes should be systematic upon discovery of DPN, and vice versa. Achieving optimal glycemic control and managing modifiable cardiovascular risk factors are essentials.

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REFERENCES

1. International Diabetes Federation. Diabetes Atlas 11th edition 2025. Available from: https://diabetesatlas.org/resources/idf-diabetes-atlas-2025/. Accessed on 10 December 2025.
2. Himeno T, Kamiya H, Nakamura J. Not out of the woods yet: diabetic neuropathy or neuropathy associated with diabetes? J Diabetes Investig. 2022;13(5):753-5.
3. Albers JW, Pop-Busui R. Diabetic neuropathy: mechanisms, emerging treatments, and subtypes. Curr Neurol Neurosci Rep. 2014;14(8):473.
4. Liu X, Xu Y, An M, Zeng Q. The risk factors for diabetic peripheral neuropathy: a meta-analysis. PloS One. 2019;14(2):e0212574.
5. Hicks CW, Selvin E. Epidemiology of peripheral neuropathy and lower extremity disease in diabetes. Curr Diabetes Rep. 2019;19(10):86.
6. Elafros MA, Andersen H, Bennett DL, Savelieff MG, Viswanathan V, Callaghan BC, et al. Towards prevention of diabetic peripheral neuropathy: clinical presentation, pathogenesis, and new treatments. Lancet Neurol. 2022;21(10):922-36.
7. Raherison RE, Razanamparany T, Andrianiaina MMA, Andrianasolo RL, Rakotomalala ADP. Factors associated with the presence of microangiopathy in type 2 diabetics outpatients in Antananarivo, Madagascar, in 2023. Int J Res Med Sci. 2025;13(4):1424-31.
8. American Diabetes Association. Standards of care in diabetes 2023. Diabetes Care. 2023;46(1):S1-292.
9. Carmichael J, Fadavi H, Ishibashi F, Shore AC, Tavakoli M. Advances in screening, early diagnosis and accurate staging of diabetic neuropathy. Front Endocrinol. 2021;12:671257.
10. Task force on the management of elevated blood pressure and hypertension of the European Society of Cardiology (ESC) and endorsed by the European Society of Endocrinology (ESE) and the European Stroke Organisation (ESO). 2024 ESC Guidelines for the management of elevated blood pressure and hypertension. Eur Heart J. 2024;45(38):3912-4018.
11. Task Force Members, ESC Committee for Practice Guidelines (CPG), ESC National Cardiac Societies. 2019 ESC/EAS guidelines for the management of dyslipidaemias: Lipid modification to reduce cardiovascular risk. Atherosclerosis. 2019;290:140-205.
12. Halimi JM, Hadjadj S, Aboyans V, Allaert FA, Artigou JY, Beaufils M, et al. Microalbuminuria and urinary albumin excretion: clinical practice guidelines. Nephrol Ther. 2007:384-91.
13. Schaper NC, van Netten JJ, Apelqvist J, Bus SA, Hinchliffe RJ, Lipsky BA, et al. Practical Guidelines on the prevention and management of diabetic foot disease (IWGDF 2019 update). Diabetes Metab Res Rev. 2020;36(1):e3266.
14. Kisozi T, Mutebi E, Kisekka M, Lhatoo S, Sajatovic M, Kaddumukasa M, et al. Prevalence, severity and factors associated with peripheral neuropathy among newly diagnosed diabetic patients attending Mulago hospital: a cross-sectional study. Afr Health Sci. 2017;17(2):463-73.
15. Ponirakis G, Elhadd T, Chinnaiyan S, Hamza AH, Sheik S, Kalathingal MA, et al. Prevalence and risk factors for diabetic neuropathy and painful diabetic neuropathy in primary and secondary healthcare in Qatar. J Diabetes Investig. 2021;12(4):592-600.

16. Agyekum JA, Yeboah K. Peripheral sensory neuropathy is associated with circulating angiopoietins in type 2 diabetes patients in Ghana. J Clin Transl Endocrinol. 2023;34:100327.
17. Khawaja N, Abu-Shennar J, Saleh M, Dahbour SS, Khader YS, Ajlouni KM. The prevalence and risk factors of peripheral neuropathy among patients with type 2 diabetes mellitus; the case of Jordan. Diabetol Metab Syndr. 2018;10:8.
18. Mekuria Negussie Y, Tilahun Bekele N. Diabetic peripheral neuropathy among adult type 2 diabetes patients in Adama, Ethiopia: health facility-based study. Sci Rep. 2024;14(1):3844.
19. Amour AA, Chamba N, Kayandabila J, Lyaruu IA, Marieke D, Shao ER, et al. Prevalence, patterns, and factors associated with peripheral neuropathies among diabetic patients at tertiary hospital in the Kilimanjaro region: descriptive cross-sectional study from north-eastern Tanzania. Int J Endocrinol. 2019;2019:5404781.
20. Vinik AI, Strotmeyer ES, Nakave AA, Patel CV. Diabetic neuropathy in older adults. Clin Geriatr Med. 2008;24(3):407-35.
21. Román-Pintos LM, Villegas-Rivera G, Rodríguez-Carrizalez AD, Miranda-Díaz AG, Cardona-Muñoz EG. Diabetic polyneuropathy in type 2 diabetes mellitus: Inflammation, oxidative stress, and mitochondrial function. J Diabetes Res. 2016;2016:1-16.
22. Corriere M, Rooparinesingh N, Kalyani RR. Epidemiology of diabetes and diabetes complications in the elderly: An emerging public health burden. Curr Diab Rep. 2013;13(6):805-13.
23. Vincent AM, Hayes JM, McLean LL, Vivekanandan-Giri A, Pennathur S, Feldman EL. Dyslipidemia-induced neuropathy in mice: the role of oxLDL/LOX-1. Diabetes. 2009;58(10):2376-85.
24. Keller JN, Hanni KB, Markesbery WR. Oxidized low-density lipoprotein induces neuronal death. J Neurochem. 2002;72(6):2601-9.
25. Pai YW, Lin CH, Lee IT, Chang MH. Prevalence and biochemical risk factors of diabetic peripheral neuropathy with or without neuropathic pain in Taiwanese adults with type 2 diabetes mellitus. Diabetes Metab Syndr. 2018;12(2):111-6.
26. Bariha PK, Tudu KM, Kujur ST. Correlation of microalbuminuria with neuropathy in type-II diabetes mellitus patients. Int J Adv Med. 2018; 5(5):1143-50.
27. Muyambi V, Agaba DC, Omolo RO, Ogwal JO, Samuel O, Semuwemba J, et al. Diabetic peripheral neuropathy and associated factors among patients attending Mbarara Regional Referral Hospital, Southwestern Uganda: a cross-sectional study. Discov Med. 2025;2(1).
28. Sendi RA, Mahrus AM, Saeed RM, Mohammed MA, Al-Dubai SAR. Diabetic peripheral neuropathy among Saudi diabetic patients: a multicenter cross-sectional study at primary health care setting. J Fam Med Prim Care. 2020;9:197-201.
29. Vinik AI, Maser RE, Mitchell BD, Freeman R. Diabetic autonomic neuropathy. Diabetes Care. 2003;26:1553-79.
30. Huang L, Zhang Y, Wang Y, Shen X, Yan S. Diabetic peripheral neuropathy is associated with higher systolic blood pressure in adults with type 2 diabetes with and without hypertension in the Chinese Han population. Can J Diabetes. 2020;44:615-23.
31. Jaiswal M, Divers J, Dabelea D, Isom S, Bell RA, Martin CL, et al. Prevalence of and risk factors for diabetic peripheral neuropathy in youth with type 1 and type 2 diabetes: SEARCH for diabetes in youth study. Diabetes Care. 2017;40(9):1226-32.
32. Jember G, Melsew YA, Fisseha B, Sany K, Gelaw AY, Janakiraman B. Peripheral sensory neuropathy and associated factors among adult diabetes mellitus patients in Bahr Dar, Ethiopia. J Diabetes Metab Disord. 2017;16:16.
33. Edwards JL, Vincent AM, Cheng HT, Feldman EL. Diabetic neuropathy: mechanisms to management. Pharmacol Ther. 2008;120(1):1-34.
34. Nisar MU, Asad A, Waqas A, Ali N, Nisar A, Qayyum MA, et al. Association of diabetic neuropathy with duration of type 2 diabetes and glycemic control. Cureus. 2015:7(8):e302.
35. Katulanda P, Ranasinghe P, Jayawardena R, Constantine GR, Sheriff MHR, Matthews DR. The prevalence, patterns and predictors of diabetic peripheral neuropathy in a developing country. Diabetol Metab Syndr. 2012;4(1):21.
36. Kuate-Tegueu C, Temfack E, Ngankou S, Doumbe J, Djientcheu VP, Kengne AP. Prevalence and determinants of diabetic polyneuropathy in a sub-Saharan African referral hospital. J Neurol Sci. 2015;355(1-2):108-12.
37. Nozawa K, Ikeda M, Kikuchi S. Association between HbA1c levels and diabetic peripheral neuropathy: a case-control study of patients with type 2 diabetes using claims data. Drugs Real World Outcomes. 2022;9(3):403-14.
38. Katulanda P, Ranasinghe P, Jayawardena R, Constantine GR, Sheriff MHR, Matthews DR. The prevalence, patterns and predictors of diabetic peripheral neuropathy in a developing country. Diabetol Metab Syndr. 2012;4(1):21.
39. Laakso M. Heart in diabetes: a microvascular disease. Diabetes Care. 2011;34(2):S145-9.

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