E-ISSN 2250-0944
ISSN 2250-1150
doi: 10.31838/ijprt/16.02. 571

Research Article

Peripheral Neuropathy in Patients with Diabetes: Clinical Spectrum and Association with Vitamin B12 Deficiency and Hypothyroidism

Irfan Ullah[1], Sidra Humayun[2*], Amir Taj Khan[3], Sarooj Ahmed[4], Gul Muhammad[5], Saima Manzoor[6]

[1]Assistant Professor, Department of Neurology, Khyber Teaching Hospital, Peshawar, Pakistan.
[2*]Associate Professor, Department of Pathology, Muhammad College of Medicine (MCM), Peshawar, Pakistan.
[3]Medical Specialist, Visiting Professor, Allied Health Sciences, Khyber Medical University, Peshawar, Pakistan.
[4]Consultant Physician, Department of Medicine, DHQ Hospital, Hafizabad, Pakistan.
[5]Assistant Professor, Department of Physiology, Rehman Medical College, Peshawar, Pakistan.
[6]Assistant Professor, HBS Medical and Dental College, Islamabad, Pakistan.

Corresponding Author: Sidra Humayun
Associate Professor, Department of Pathology, Muhammad College of Medicine (MCM), Peshawar, Pakistan.
Email: drsidrafarooq4@gmail.com
Received: 14.06.2026, Revised: 24.08.2026, Accepted: 05.09.2026

ABSTRACT

Background: Peripheral neuropathy may occur with diabetes mellitus and cause foot ulceration, functional disability, gait disturbance, pain, and sensory loss, and is one of the most common chronic complications of diabetes mellitus. While long-standing hyperglycemia is an important precipitating factor, other potentially reversible causes like vitamin B12 deficiency and hypothyroidism can play a role in the onset or exacerbation of neuropathic symptoms.

Objective: To evaluate the clinical spectrum of peripheral neuropathy in patients with diabetes mellitus and determine its association with vitamin B12 deficiency and hypothyroidism.

Methodology: This cross-sectional analytical study was conducted at Muhammad Teaching Hospital, Peshawar, from January 2025 to June 2025. The total number of patients enrolled was 67 diabetic mellitus patients, who were consecutively sampled. Symptoms and signs of peripheral neuropathy were evaluated in participants, including numbness, paresthesias, burning sensation, neuropathic pain, abnormal monofilament sensation, impaired vibration perception, and a decrease in ankle reflexes. Serum vitamin B12 level, thyroid-stimulating immunoglobulin, thyroid-stimulating antibody, HbA1c, and hematological parameters were assessed in the laboratory. Association of neuropathy with vitamin B12 deficiency, hypothyroidism, duration of diabetes, glycemic control, and metformin use were statistically evaluated.

Results: Peripheral neuropathy was identified in 39 patients (58.2%). Numbness was the most frequent manifestation, followed by paresthesia, burning sensation, and impaired vibration perception. Vitamin B12 deficiency was present in 21 patients (31.3%), whereas hypothyroidism was detected in 15 patients (22.4%). Neuropathy occurred in 81.0% of patients with vitamin B12 deficiency compared with 47.8% of those without deficiency ($p = 0.011$). Similarly, 86.7% of hypothyroid patients had neuropathy compared with **50.0%** of euthyroid patients ($p = 0.012$). Vitamin B12 deficiency, hypothyroidism, diabetes duration greater than 10 years, and HbA1c ≥8% remained significant predictors of neuropathy on multivariable analysis.

Conclusion: Peripheral neuropathy was common among patients with diabetes and was significantly associated with vitamin B12 deficiency and hypothyroidism. Longer duration of diabetes and poor glycemic control were additional contributing factors. Assessment of vitamin B12 and thyroid status may help identify treatable causes that can aggravate neuropathic manifestations in diabetic patients.

Keywords: Diabetes Mellitus, Peripheral Neuropathy, Vitamin B12 Deficiency, Hypothyroidism, Hba1c, Diabetic Complications.

INTRODUCTION

Diabetes mellitus is a very common chronic metabolic disease that is associated with numerous vascular and neurological complications and is defined by chronic hyperglycemia. Peripheral neuropathy is one of the microvascular complications that may lead to progressive sensory and motor dysfunction. Patients can suffer numbness, tingling, burning pain, loss of protection sensation, decreased reflexes and loss of vibration sense. As the disease progresses, these changes may lead to falls, foot ulceration, infection, and lower-limb amputation, which can lead to increased morbidity, and lower quality of life (1, 2).

There are several mechanisms that interact and lead to diabetic peripheral neuropathy. Chronic hyperglycemia leads to oxidative stress, Advanced Glycosylated End Products (AGEs) formation, endothelial dysfunction, microvascular ischemia, inflammatory changes, and metabolic injury to Peripheral nerves. The risk is usually higher when a person has diabetes for a longer time and doesn't get their blood sugar under control. However, diabetic patients may suffer from other metabolic or nutritional abnormalities that can also give rise to similar neuro manifestations, so as to differentiate potentially correctable contributors to neuro manifestations from those due to diabetic neuropathy alone (3-5).

One of these factors is especially important - the lack of vitamin B12. Vitamin B12 plays a vital role in the formation of myelin, metabolism and normal function of the central and peripheral nervous systems. Deficiency may lead to paresthesias, numbness, loss of proprioception, abnormal gait, muscle weakness, and peripheral nerve damage. The symptoms mimic diabetic peripheral neuropathy (DPN). Moreover, treatment with metformin, a standard treatment for type 2 diabetes, could cause a decrease in absorption of vitamin B12 and the risk for deficiency in vulnerable patients (6-8).

Peripheral nerve function can also be affected by hypothyroidism. Thyroid hormone deficiency can result in metabolic slowing, edema of tissues, impaired axonal transport, and abnormalities of nerve conduction. Neurological symptoms can include sensory symptoms, decreased reflexes, muscle weakness, and entrapment neuropathies. If hypothyroidism is accompanied by diabetes mellitus these diseases may interact and exacerbate or even worsen peripheral nerve dysfunction (9-11).

It is clinically important to recognize the vitamin B12 deficiency and hypothyroidism because both conditions are potentially treatable. Diabetic peripheral neuropathy should not be considered the only cause of all neurologic symptoms, though, which otherwise could be corrected by improvement of the metabolic control of the diabetes. Thus, assessment of nutritional and endocrine status may be used to enhance clinical evaluation and better fine-tune treatment (12, 13).

Despite the high burden of diabetes-related neurological complications, local evidence regarding the combined association of vitamin B12 deficiency and hypothyroidism with peripheral neuropathy remains limited. The present study was therefore conducted to describe the clinical spectrum of peripheral neuropathy among patients with diabetes mellitus and to assess its association with vitamin B12 deficiency, hypothyroidism, duration of diabetes, and glycemic control.

METHODOLOGY

This cross-sectional analytical study was conducted at Muhammad Teaching Hospital, Peshawar, from January 2025 to June 2025. A total of 67 patients with diabetes mellitus were enrolled during the study period. Patients of either sex, aged 18 years and above, with a confirmed diagnosis of diabetes mellitus were considered eligible for inclusion. Patients with known neurological disorders unrelated to diabetes, chronic alcohol use, advanced renal or hepatic disease, use of neurotoxic medications, or other established causes of peripheral neuropathy were excluded to reduce the influence of potential confounding factors.

Participants were recruited through a non-probability consecutive sampling technique from patients attending the medical outpatient and inpatient departments. After obtaining informed consent, relevant demographic and clinical information was recorded on a structured data collection form. Variables included age, sex, duration of diabetes, treatment modality, metformin use, smoking status, associated comorbidities, and history of neuropathic symptoms. Glycemic control was assessed using glycated hemoglobin (HbA1c), and patients were categorized according to the predefined study criteria.

Peripheral neuropathy was evaluated by a detailed history and neurological examination. Patients were assessed for lack of sensation (numbness), tingling or paresthesias, burning sensation, neuropathic pain, muscle weakness, balance, vibration perception, ankle reflexes, and protective sensation. Loss of protective

sensation was measured by assessing the break point of a 10-g monofilament over the standard bony prominences of the lower limbs, and vibration perception was measured by a 128-Hz tuning fork over the standard bony prominence of the lower limbs. Neuropathy was diagnosed and was either classified as present or absent based on the compatible symptoms and abnormal neurological findings or were further classified as mild, moderate or severe based upon the clinical scoring criteria used in the study.

Laboratory assessment of venous blood sample was done under aseptic condition. Standard laboratory measurements were used to test serum vitamin B12 level, thyroid-stimulating immunoglobulin (TSI), thyroid-stimulating immunoglobulin (TSH), free thyroxine (if necessary), hemoglobin A1c, hemoglobin, and other routine biochemical parameters. The level of vitamin B12 intake was defined as low, borderline, or adequate by using the laboratory reference range. The serum TSH and thyroid hormone levels were measured to assess the thyroid status, and patients were classified as hypothyroid or euthyroid. The coexistence of vitamin B12 deficiency and hypothyroidism was also noted, to assess its association with peripheral neuropathy.

The data were collected and analyzed in SPSS-IBM statistics. Age, duration of diabetes, HbA1c, vitamin B12 level, and TSH were reported as mean ± standard deviation or median (interquartile range) based on the distribution of the data. Categorical variables were summarized in frequency and percentage. Association of categorical variables with peripheral neuropathy was determined by the chi-square test or Fisher's exact test. For continuous variables, independent-samples t-test or Mann–Whitney U test, as applicable, was used. Multivariable binary logistic regression was used to determine independent predictors for peripheral neuropathy after adjustment for potential confounders (age, duration of diabetes, glycemic control, vitamin B12 deficiency, hypothyroidism, and metformin use). Odds ratios with 95% confidence intervals were presented and statistical significance was defined as $p < 0.05$.

RESULTS

There were 67 patients with diabetes mellitus in the study. The mean age of the participants was 54.8 ± 10.6 years, ranging from 32 to 76 years. Most participants were aged 51–60 years (25, 37.3%), followed by those aged >60 years (18, 26.9%). There were 38 males (56.7%) and 29 females (43.3%). The mean duration of diabetes was 9.6 ± 5.1 years, and the mean HbA1c level was 8.4 ± 1.5%. Forty-five patients (67.2%) were taking metformin alone or with other glucose-lowering therapy. Thirty patients (44.8%) had hypertension and twenty-five (37.3%) had dyslipidaemia.

Table 1. Baseline Demographic and Diabetes-Related Characteristics of Study Participants (N = 67)

Variable	n (%) / Mean ± SD
Age, years	54.8 ± 10.6
31–40 years	6 (9.0)
41–50 years	18 (26.9)
51–60 years	25 (37.3)
>60 years	18 (26.9)
Male	38 (56.7)
Female	29 (43.3)
Duration of diabetes, years	9.6 ± 5.1
Diabetes duration >10 years	29 (43.3)
HbA1c, %	8.4 ± 1.5
HbA1c ≥8%	39 (58.2)
Metformin use	45 (67.2)
Insulin use	24 (35.8)
Hypertension	30 (44.8)
Dyslipidemia	25 (37.3)
Chronic kidney disease	8 (11.9)
Current smoking	12 (17.9)

Overall 39/67 patients (58.2%) had peripheral neuropathy. The most common symptom was numbness of the feet (31, 46.3%), followed by the development of a sensation of tingling or paresthesias (29, 43.3%), burning sensation (25, 37.3%) and neuropathic pain (22, 32.8%).

Twenty-four patients (35.8%) had a decrease in protective sensation on monofilament examination, and 27 patients (40.3%) had a decrease in vibration perception. Ankle reflexes were decreased in 21 patients (31.3%). Twenty-three of the neuropathy patients (72.7%) had mild disease, 14 (43.6%) had moderate disease, and 8 (20.5%) had severe neuropathy.

Table 2. Clinical Spectrum and Severity of Peripheral Neuropathy

Clinical characteristic	n (%)
Peripheral neuropathy present	39 (58.2)
No peripheral neuropathy	28 (41.8)
Numbness	31 (46.3)
Tingling/paresthesia	29 (43.3)
Burning sensation	25 (37.3)
Neuropathic pain	22 (32.8)
Muscle weakness	13 (19.4)
Balance difficulty	12 (17.9)
Reduced vibration perception	27 (40.3)
Abnormal monofilament sensation	24 (35.8)
Reduced ankle reflexes	21 (31.3)

Neuropathy Severity among Affected Patients (N = 39)

Severity	n (%)
Mild	17 (43.6)
Moderate	14 (35.9)
Severe	8 (20.5)

The mean serum vitamin B12 level was 286.5 ± 132.8 pg/mL. Vitamin B12 deficiency was found in 21 patients (31.3%) and 12 patients (17.9%) had borderline levels of vitamin B12. Vitamin B12 levels in the remaining 34 (50.7%) were in normal range. The mean TSH was 4.2 ± 3.1 mIU/L and 15 patients (22.4%) had hypothyroidism. Seven patients (10.4%) had both a vitamin B12 deficiency and hypothyroidism at the same time.

Table 3. Laboratory and Endocrine Profile of Study Participants

Variable	n (%) / Mean ± SD
Serum vitamin B12, pg/mL	286.5 ± 132.8
Vitamin B12 deficient	21 (31.3)
Borderline vitamin B12	12 (17.9)
Normal vitamin B12	34 (50.7)
TSH, mIU/L	4.2 ± 3.1
Hypothyroidism	15 (22.4)
Euthyroid state	52 (77.6)
Both B12 deficiency and hypothyroidism	7 (10.4)
HbA1c, %	8.4 ± 1.5
Hemoglobin, g/dL	12.8 ± 1.7

Peripheral neuropathy was significantly more common among patients with vitamin B12 deficiency. Of the 21 patients with vitamin B12 deficiency, 17 (81.0%) had peripheral neuropathy, compared with 22 of 46 patients (47.8%) without vitamin B12 deficiency ($p = 0.011$). Similarly, neuropathy was detected in 13 of 15 patients (86.7%) with hypothyroidism compared with 26 of 52 patients (50.0%) with normal thyroid status ($p = 0.012$). Patients with both vitamin B12 deficiency and hypothyroidism had the highest frequency of peripheral neuropathy, with 6 of 7 patients (85.7%) being affected.

Patients with vitamin B12 deficiency were much more likely to have peripheral neuropathy. There were 22 patients without vitamin B12 deficiency and 17 of these (81.0%) had peripheral neuropathy, whereas 22 of the 46 patients with vitamin B12 deficiency (47.8%) did not ($p = 0.011$). Likewise, there was a significantly higher prevalence of neuropathy in

the hypothyroidism group (13/15, 86.7%) than in the normal group (26/52, 50.0%) (p = 0.012). Peripheral neuropathy was most common in patients with both vitamin B12 deficiency and hypothyroidism who had 6/7 patients (85.7%). Neuropathy was also significantly related to the duration of diabetes and glycemic control. Peripheral neuropathy was found in 23 of 29 (79.3%) patients who had diabetes for over 10 years, but in 16 of 38 (42.1%) who had diabetes for less than 10 years (p = 0.002). Likewise, neuropathy occurred in 28 of 39 patients (71.8%) with HbA1c ≥8% compared with 11 of 28 patients (39.3%) with HbA1c below 8% (p = 0.008).

Table 4. Association of Clinical and Biochemical Factors with Peripheral Neuropathy

Variable	Neuropathy present n (%)	Neuropathy absent n (%)	p-value
Vitamin B12 deficiency	17 (81.0)	4 (19.0)	**0.011**
No B12 deficiency	22 (47.8)	24 (52.2)	
Hypothyroidism	13 (86.7)	2 (13.3)	**0.012**
Euthyroid	26 (50.0)	26 (50.0)	
Diabetes duration >10 years	23 (79.3)	6 (20.7)	**0.002**
Diabetes duration ≤10 years	16 (42.1)	22 (57.9)	
HbA1c ≥8%	28 (71.8)	11 (28.2)	**0.008**
HbA1c <8%	11 (39.3)	17 (60.7)	
Metformin use	30 (66.7)	15 (33.3)	**0.041**
No metformin use	9 (40.9)	13 (59.1)	

Vitamin B12 deficiency, hypothyroidism, longer duration of diabetes and poor glycemic control were independently associated with peripheral neuropathy on multivariable logistic regression. Neuropathy was about 3.4-times more likely in vitamin B12 deficient patients than in nondeficient patients (AOR = 3.41; 95% CI = 1.05–11.06; p = 0.041). The odds of developing neuropathy were close to 4.2 times higher in those with hypothyroidism (AOR = 4.17; 95% CI: 1.02 – 17.09; p = 0.047). Diabetes duration greater than 10 years was another significant predictor (AOR = 3.76; 95% CI: 1.19–11.90; p = 0.024), while HbA1c ≥8% was associated with increased odds of neuropathy (AOR = 2.94; 95% CI: 1.01–8.59; p = 0.049).

Table 5. Multivariable Logistic Regression for Predictors of Peripheral Neuropathy

Predictor	Adjusted OR	95% CI	p-value
Vitamin B12 deficiency	3.41	1.05–11.06	0.041
Hypothyroidism	4.17	1.02–17.09	0.047
Diabetes duration >10 years	3.76	1.19–11.90	0.024
HbA1c ≥8%	2.94	1.01–8.59	0.049
Metformin use	1.83	0.57–5.89	0.310
Age >60 years	1.52	0.45–5.15	0.501

Overall, peripheral neuropathy affected more than half of the diabetic patients in the study. Sensory manifestations, particularly numbness, paresthesia, and impaired vibration perception, constituted the dominant clinical spectrum. Vitamin B12 deficiency and hypothyroidism showed significant associations with neuropathy, while prolonged diabetes duration and suboptimal glycemic control further increased the likelihood of neurological involvement.

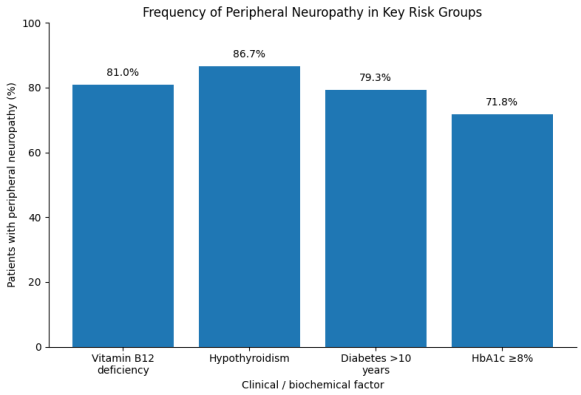

Figure 1. Frequency of Peripheral Neuropathy among Diabetic Patients According To Major Clinical and Biochemical Risk Factors

Peripheral neuropathy was most frequent among patients with hypothyroidism (86.7%), followed by vitamin B12 deficiency (81.0%), diabetes duration >10 years (79.3%), and HbA1c ≥8% (71.8%).

DISCUSSION

The present study found that peripheral neuropathy was common among patients with diabetes mellitus, affecting 58.2% of the study population. The clinical picture was mainly sensory, with numbness, tingling or paresthesia, burning sensation, neuropathic pain, and impaired vibration perception being the most frequently observed manifestations. Loss of protective sensation and reduced ankle reflexes were also documented in a considerable proportion of patients. Among those with neuropathy, mild disease was most frequent, followed by moderate and severe neuropathy. These findings indicate that peripheral nerve involvement may already be established in a substantial proportion of patients before severe neurological disability develops (14, 15).

The association of peripheral neuropathy and Vitamin B12 deficiency was found to be significant. The presence of neuropathy was noted in 81.0% of the vitamin B12 deficient patients and 47.8% of the non-vitamin B12 deficient patients. In addition, the association of vitamin B12 deficiency with neuropathy persisted after multivariable analysis with an adjusted odd ratio (AOR) of 3.41. Vitamin B12 is important for the production of myelin, for the metabolism of neurons and for normal nerve function. The deficiency, therefore, can cause sensory disturbances that can be similar to or even aggravate diabetic neuropathy. This is especially true in individuals who have diabetes, where vitamin B12 deficiency can occur with chronic metabolic nerve injury and could worsen neurological symptoms (16-18).

Metformin use was common in the study population, with approximately two-thirds of patients receiving the drug. The use of metformin was associated with neuropathy, but after controlling for other variables, it was not an independent predictor. The present finding indicates that there are other factors, such as vitamin B12 status, diabetes duration and glycemic control, that could be involved in the association of metformin and neuropathy. Some patients have been reported to have decreased absorption of vitamin B12 during long-term use of metformin. Thus, in the case of prolonged metformin therapy, patients with sensory symptoms should be assessed for their B12 status although all neurological symptoms are not necessarily attributable to metformin (19).

Another key factor with peripheral neuropathy was hypothyroidism. More hypothyroid patients (86.7%) were found to have neuropathy than euthyroid patients (50.0%). The odds ratio for hypothyroidism and neuropathy were even higher after adjustment for potential confounders (4.17). Peripheral nerve function can be affected by thyroid hormone deficiency via reduced metabolism, axonal transport disruption, tissue oedema and changes in nerve conduction. In hypothyroidism concurrent with diabetes mellitus, these mechanisms could contribute the chronic metabolic and microvascular injury of hyperglycemia. This finding of a high proportion of patients with both vitamin B12 deficiency and hypothyroidism who also developed neuropathy further suggests that there could be more than one reversible metabolic abnormality at play causing nerve dysfunction.

Other factors significantly associated with peripheral neuropathy were longer duration of

diabetes and poor glycemic control. Neuropathy was more common in diabetic patients with a disease duration of more than 10 years (79.3%) than in those with a shorter duration (42.1%). Patients with higher levels of HbA1c (8% or greater) also had a disproportionately high prevalence of neuropathy compared with the patients with better glycemic control. Long-standing hyperglycemia may lead to peripheral nerve oxidative stress, endothelial dysfunction, microvascular ischemia, inflammation, and metabolic abnormalities. As a result, the longer someone has diabetes, the greater the likelihood of damage to their nervous system over time, if they don't control their blood sugar well (19, 20).

This study's results highlight that peripheral neuropathy in a diabetic patient is likely to be of a multifactorial etiology. Nutritional deficiency and endocrine dysfunction can also play a significant role in the clinical picture, although prolonged hyperglycaemia is important. Treatment for peripheral neuropathy should thus involve an evaluation for glycemic control as well as an evaluation for potentially reversible causes, including B12 deficiency and hypothyroidism. These abnormalities may be identified and corrected to prevent further neurological decline and/or help to manage their symptoms.

This study had several limitations. The relatively small sample size of 67 patients, single-center setting, and cross-sectional design may limit the generalizability of the findings and do not allow a definite causal relationship to be established. Neuropathy was primarily assessed clinically, while electrophysiological nerve-conduction studies were not included in all participants. Additional biomarkers of functional vitamin B12 deficiency, such as methylmalonic acid and homocysteine, were also not assessed. Future multicenter prospective studies with larger sample sizes should evaluate whether correction of vitamin B12 deficiency and hypothyroidism results in improvement in neuropathic symptoms, clinical scores, and nerve-conduction parameters.

CONCLUSION

Peripheral neuropathy was frequently observed among patients with diabetes mellitus and predominantly manifested as sensory abnormalities, including numbness, paresthesia, burning sensation, neuropathic pain, and impaired vibration perception. Vitamin B12 deficiency and hypothyroidism were significantly and independently associated with peripheral neuropathy, while longer duration of diabetes and poor glycemic control were additional important predictors. These findings suggest that diabetic peripheral neuropathy should not be attributed to hyperglycemia alone. Screening for vitamin B12 deficiency and thyroid dysfunction, particularly in patients with longstanding diabetes or neuropathic symptoms, may assist in identifying potentially correctable contributors to peripheral nerve dysfunction.

REFERENCES

1. 1.Miyan Z, Waris N. Association of vitamin B(12) deficiency in people with type 2 diabetes on metformin and without metformin: a multicenter study, Karachi, Pakistan. BMJ open diabetes research & care. 2020;8(1)DOI: 10.1136/bmjdrc-2019-001151.
2. 2.Baxi H, Habib A, Hussain MS, Hussain S, Dubey K. Prevalence of peripheral neuropathy and associated pain in patients with diabetes mellitus: Evidence from a cross-sectional study. Journal of diabetes and metabolic disorders. 2020;19(2):1011-7 DOI: 10.1007/s40200-020-00597-y.
3. 3.Groener JB, Jende JME, Kurz FT, Kender Z, Treede RD, Schuh-Hofer S, et al. Understanding Diabetic Neuropathy-From Subclinical Nerve Lesions to Severe Nerve Fiber Deficits: A Cross-Sectional Study in Patients With Type 2 Diabetes and Healthy Control Subjects. Diabetes. 2020;69(3):436-47 DOI: 10.2337/db19-0197.
4. 4.Gylfadottir SS, Christensen DH, Nicolaisen SK, Andersen H, Callaghan BC, Itani M, et al. Diabetic polyneuropathy and pain, prevalence, and patient characteristics: a cross-sectional questionnaire study of 5,514 patients with recently diagnosed type 2 diabetes. Pain. 2020;161(3):574-83 DOI: 10.1097/j.pain.0000000000001744.
5. 5.Braffett BH, Gubitosi-Klug RA, Albers JW, Feldman EL, Martin CL, White NH, et al. Risk Factors for Diabetic Peripheral Neuropathy and Cardiovascular Autonomic Neuropathy in the Diabetes Control and Complications Trial/Epidemiology of Diabetes Interventions and Complications (DCCT/EDIC) Study. Diabetes. 2020;69(5):1000-10 DOI: 10.2337/db19-1046.

6. 6.Mayeda L, Katz R, Ahmad I, Bansal N, Batacchi Z, Hirsch IB, et al. Glucose time in range and peripheral neuropathy in type 2 diabetes mellitus and chronic kidney disease. BMJ open diabetes research & care. 2020;8(1)DOI: 10.1136/bmjdrc-2019-000991.
7. 7.Mizokami-Stout KR, Li Z, Foster NC, Shah V, Aleppo G, McGill JB, et al. The Contemporary Prevalence of Diabetic Neuropathy in Type 1 Diabetes: Findings From the T1D Exchange. Diabetes care. 2020;43(4):806-12 DOI: 10.2337/dc19-1583.
8. 8.Didangelos T, Karlafti E, Kotzakioulafi E, Margariti E, Giannoulaki P, Batanis G, et al. Vitamin B12 Supplementation in Diabetic Neuropathy: A 1-Year, Randomized, Double-Blind, Placebo-Controlled Trial. Nutrients. 2021;13(2)DOI: 10.3390/nu13020395.
9. 9.Kamrul-Hasan AB, Alam MS, Chanda PK, Selim S. Serum Vitamin B12 Levels in Patients with Type 2 Diabetes Mellitus on Metformin Compared to those Never on Metformin: A Cross-sectional Study from Bangladesh. Mymensingh medical journal : MMJ. 2021;30(4):913-20.
10. 10. Alam MS, Kamrul-Hasan A, Kalam ST. Serum vitamin B12 status of patients with type 2 diabetes mellitus on metformin: A single-center cross-sectional study from Bangladesh. J Family Med Prim Care. 2021;10(6):2225-9 DOI: 10.4103/jfmpc.jfmpc_2388_20.
11. 11. Abuzinadah AR, Alkully HS, Alanazy MH, Alrawaili MS, Milyani HA, AlAmri B, et al. Translation, validation, and diagnostic accuracy of the Arabic version of the Michigan neuropathy screening instrument. Medicine (Baltimore). 2021;100(44):e27627 DOI: 10.1097/md.0000000000027627.
12. 12. Oh TJ, Song Y, Jang HC, Choi SH. SUDOSCAN in Combination with the Michigan Neuropathy Screening Instrument Is an Effective Tool for Screening Diabetic Peripheral Neuropathy. Diabetes & metabolism journal. 2022;46(2):319-26 DOI: 10.4093/dmj.2021.0014.
13. 13. Li C, Wang W, Ji Q, Ran X, Kuang H, Yu X, et al. Prevalence of painful diabetic peripheral neuropathy in type 2 diabetes mellitus and diabetic peripheral neuropathy: A nationwide cross-sectional study in mainland China. Diabetes Res Clin Pract. 2023;198:110602 DOI: 10.1016/j.diabres.2023.110602.
14. 14. Wang W, Ji Q, Ran X, Li C, Kuang H, Yu X, et al. Prevalence and risk factors of diabetic peripheral neuropathy: A population-based cross-sectional study in China. Diabetes Metab Res Rev. 2023;39(8):e3702 DOI: 10.1002/dmrr.3702.
15. 15. Jin HY, Lee KA, Kim YJ, Gwak IS, Park TS, Yeom SW, et al. Bidirectional association between diabetic peripheral neuropathy and vitamin B12 deficiency: Two longitudinal 9-year follow-up studies using a national sample cohort. Prim Care Diabetes. 2023;17(5):436-43 DOI: 10.1016/j.pcd.2023.06.006.
16. 16. Yang R, Yu H, Wu J, Chen H, Wang M, Wang S, et al. Metformin treatment and risk of diabetic peripheral neuropathy in patients with type 2 diabetes mellitus in Beijing, China. Front Endocrinol (Lausanne). 2023;14:1082720 DOI: 10.3389/fendo.2023.1082720.
17. 17. Gao L, Ran X, Liu X, Shen X, Chen S, Liu F, et al. The effects of daily dose and treatment duration of metformin on the prevalence of vitamin B12 deficiency and peripheral neuropathy in Chinese patients with type 2 diabetes mellitus: A multicenter cross-sectional study. Journal of diabetes. 2023;15(9):765-76 DOI: 10.1111/1753-0407.13428.
18. 18. Huynh DT, Nguyen NT, Do MD. Vitamin B12 deficiency in diabetic patients treated with metformin: A cross-sectional study. PLoS One. 2024;19(4):e0302500 DOI: 10.1371/journal.pone.0302500.
19. 19. Duan X, Zhang T, Wang K. Causal relationship between hypothyroidism and peripheral neuropathy: a Mendelian randomization study of European ancestry. Front Endocrinol (Lausanne). 2024;15:1436823 DOI: 10.3389/fendo.2024.1436823.
20. 20. Asghar S, Tanvir H, Riaz A, Ejaz MH, Akram M, Chowdhury Evan AM, et al. Prevalence of Vitamin B12 Deficiency in Patients With Type 2 Diabetes Mellitus on Metformin Therapy: A Cross-Sectional Study. Cureus. 2024;16(10):e72184 DOI: 10.7759/cureus.72184.