

Original Article

Association of diabetic neuropathy with depression and anxiety in type 2 diabetes mellitus: A cross-sectional study

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Abstract

Psychological burden of diabetic neuropathy has received less attention than its physical consequences, particularly in Southeast Asia. Sociocultural factors, healthcare access, and differences in diabetes management may influence psychological outcomes, yet data from Indonesia remain scarce. The aim of this study was to evaluate the association of diabetic neuropathy severity with symptoms of depression and anxiety among patients with type 2 diabetes mellitus (T2DM). A cross-sectional study was conducted among adult patients with T2DM attending Endocrinology Outpatient Clinic of Dr. Zainoel Abidin Hospital, Banda Aceh, Indonesia. Diabetic neuropathy was assessed using Total Neuropathy Score (TNS), while depressive and anxiety symptoms were evaluated using Patient Health Questionnaire-9 (PHQ-9) and Generalized Anxiety Disorder-7 (GAD-7), respectively. A total of 102 patients were included in the final analysis. TNS scores were significantly higher in patients with depression than in those without depression ($p=0.007$). Similarly, TNS scores were significantly higher in patients with anxiety than in those without anxiety ($p=0.040$). Neuropathy severity demonstrated a weak positive correlation with depression severity ($r=0.332$, $p<0.001$) and a weak positive correlation with anxiety severity ($r=0.200$, $p=0.044$). Linear regression analysis showed that greater neuropathy severity was significantly associated with higher PHQ-9 scores, with each one-point increase in TNS corresponding to a 0.230-point increase in depression score ($B=0.230$; $p=0.013$; $R^2=0.060$). No significant association was observed between TNS and GAD-7 scores ($B=0.129$; $p=0.141$; $R^2=0.022$), despite a positive trend. In conclusion, greater diabetic neuropathy severity was associated with depressive symptoms, while the association with anxiety was weaker and lost significance after linear regression. Incorporating routine depression screening into the clinical evaluation of diabetic neuropathy may facilitate more comprehensive patient management.

Keywords: Type 2 diabetes mellitus, diabetic neuropathy, depression, anxiety, Total Neuropathy Score

Introduction

Type 2 diabetes mellitus (T2DM) is a major global public health challenge, affecting more than 500 million individuals worldwide and contributing substantially to morbidity, mortality, and



healthcare expenditures [1]. In addition to its metabolic consequences, T2DM is associated with a wide range of chronic complications that adversely affect physical, functional, and psychological well-being [2]. Among these complications, diabetic neuropathy is one of the most prevalent and debilitating manifestations, occurring in approximately 30–50% of patients with long-standing diabetes [3]. Diabetic neuropathy is characterized by progressive nerve damage resulting from chronic hyperglycemia, oxidative stress, microvascular dysfunction, and persistent inflammation, leading to symptoms such as pain, numbness, paresthesia, sensory loss, and impaired mobility [4].

Beyond its physical manifestations, diabetic neuropathy has important psychological consequences [5]. Chronic neuropathic pain, functional limitations, sleep disturbances, and reduced quality of life may contribute to the development of mental health disorders, particularly depression and anxiety [6]. These psychological conditions are highly prevalent among patients with T2DM and have been associated with poor glycemic control, reduced treatment adherence, increased healthcare utilization, and worse clinical outcomes [7]. Previous studies have demonstrated that depression and anxiety occur more frequently among patients with diabetic complications than among those without complications, suggesting a potential role of diabetic neuropathy in the development of psychological distress [7–10].

Several biological mechanisms may explain the association between diabetic neuropathy and mental health disorders [11,12]. Chronic systemic inflammation, characterized by elevated levels of pro-inflammatory cytokines such as interleukin-6 (IL-6) and tumor necrosis factor- α (TNF- α), has been implicated in both neuropathic damage and the pathogenesis of depression and anxiety [13]. Furthermore, chronic pain may induce neuroplastic changes within central nervous system pathways involved in mood regulation, thereby increasing susceptibility to psychological disorders [14]. The coexistence of diabetic neuropathy, depression, and anxiety may create a vicious cycle in which psychological distress worsens self-management behaviors, leading to poorer glycemic control and further progression of neuropathic complications [2].

Although the association between diabetes and mental health has been extensively investigated, evidence specifically evaluating the association between diabetic neuropathy and both depression and anxiety remains limited, particularly in Southeast Asia. Sociocultural differences, variations in healthcare access, and disparities in diabetes management may influence the burden of psychological disorders among patients with diabetic neuropathy. In Indonesia, data regarding the psychological impact of diabetic neuropathy are scarce, despite the increasing prevalence of diabetes and its complications. Therefore, the aim of this study was to evaluate the association between diabetic neuropathy and depression and anxiety among patients with T2DM.

Methods

Study design and setting

A cross-sectional analytical study was conducted at the Endocrinology Outpatient Clinic of Dr. Zainoel Abidin Hospital, Banda Aceh, Indonesia, in 2025. Adult T2DM patients with diabetic neuropathy were recruited using a total sampling approach based on predefined eligibility criteria. Demographic variables included age and sex, while clinical variables encompassed duration of T2DM and glycemic control assessed by glycated hemoglobin (HbA_{1c}). Diabetic neuropathy severity was evaluated using the Total Neuropathy Score (TNS) [15]. Depressive symptoms were assessed using the Patient Health Questionnaire-9 (PHQ-9) and anxiety symptoms were evaluated using the Generalized Anxiety Disorder-7 (GAD-7) [16,17].

Sample size, sampling method, and eligibility criteria

As a total sampling strategy was applied, no formal sample size calculation was performed. Inclusion criteria comprised adult patients aged ≥ 18 years with a confirmed diagnosis of diabetic neuropathy who attended the Endocrinology Outpatient Clinic during October and November 2025. Eligible participants were required to be clinically stable, cooperative, and capable of providing reliable information through interview-based assessments, including completion of validated questionnaires (TNS, PHQ-9, and GAD-7). Patients with T2DM and concomitant

chronic kidney disease, chronic infectious diseases (including human immunodeficiency virus infection), autoimmune disorders (such as systemic lupus erythematosus and rheumatoid arthritis), hyperthyroidism, or active malignancy undergoing chemotherapy were excluded. In addition, patients with documented central nervous system disorders—including stroke, Parkinson's disease, or dementia—were not eligible due to the potential impact on cognitive and neurological assessment.

Assessment of diabetic neuropathy

Diabetic neuropathy was assessed using the TNS, a validated instrument comprising ten domains: sensory symptoms, motor symptoms, autonomic symptoms, pin sensibility, vibration sensibility, muscle strength, deep tendon reflexes, vibration sensibility (QST vibration), sural amplitude, and peroneal amplitude [15]. Each domain is scored from 0 to 4, resulting in a total score ranging from 0 to 40 with higher scores indicating greater neuropathy severity.

Assessment of depression and anxiety

Depressive symptoms were assessed using the PHQ-9, a validated self-administered questionnaire consisting of nine items [16]. Each item is scored on a 4-point Likert scale from 0 (not at all) to 3 (nearly every day), yielding a total score ranging from 0 to 27, with higher scores indicating greater depressive symptom severity. A PHQ-9 score ≥ 5 was classified as depression, whereas a score < 5 was classified as no depression.

Anxiety symptoms were assessed using the GAD-7 questionnaire, a validated self-administered instrument comprising seven items scored on a 4-point Likert scale from 0 (not at all) to 3 (nearly every day) [17]. Total scores range from 0 to 21, with higher scores indicating greater anxiety symptom severity. A GAD-7 score ≥ 5 was classified as anxiety, whereas a score < 5 was classified as no anxiety.

Statistical analysis

Differences in TNS scores between patients with and without depression and anxiety were analyzed using the Mann–Whitney U test. Correlations between TNS scores and PHQ-9 and GAD-7 scores were evaluated using Spearman's correlation test. Correlation coefficients were interpreted as very weak ($r < 0.20$), weak ($r = 0.20–0.39$), moderate ($r = 0.40–0.59$), strong ($r = 0.60–0.79$), and very strong ($r \geq 0.80$). Further associations between diabetic neuropathy and depression and anxiety scores were evaluated using linear regression analysis. Regression coefficients (B) and corresponding p -values were reported. All statistical analyses were performed using SPSS Version 25.0 (IBM Corp., Armonk, NY, USA), with statistical significance defined as two-tailed $p < 0.05$.

Results

Characteristics of the included patients

A total of 102 patients with T2DM were included in the analysis and their characteristics are presented in **Table 1**. The mean age was 57.9 ± 8.6 years, and the proportion of middle-aged adults was nearly threefold higher than that of older adults (73.5% vs 26.5%). Sex distribution was relatively balanced, with a slight predominance of females (55.9% vs 44.1%). Educational attainment was predominantly at the tertiary level (bachelor's and postgraduate degrees), accounting for 46.0% of the cohort, exceeding both secondary education (23.5%) and primary education levels. Most patients were married (90.2%), and a majority were not employed (63.7%), representing nearly twice the proportion of employed individuals. Despite this, most patients reported engagement in physical activity (70.6%), more than double the proportion of inactive individuals.

Hypertension was the most frequent comorbidity (29.4%), followed by combined hypertension and dyslipidemia (14.7%) (**Table 1**). The median duration of diabetes was 12 years, with a markedly higher proportion of patients with disease duration > 10 years (57.8%) compared with those < 5 years (10.8%). The most common treatment regimen was a combination of oral hypoglycemic agents and basal insulin (35.3%), nearly twice as frequent as oral monotherapy (19.6%). Nutritional status was characterized by a predominance of overweight (41.2%) and

obesity (38.2%), which together accounted for 79.4% of the cohort, substantially exceeding the proportion of normal weight (19.6%) and underweight (1.0%) individuals. The median HbA1c level was 8.65%, indicating suboptimal glycemic control, with nearly half of the patients showing HbA1c >9% (45.1%), compared with only 12.7% achieving HbA1c <7%. The median TNS was 10 (range 1–25), indicating predominantly mild-to-moderate neuropathy (**Table 1**).

Table 1. Characteristics of the included patients (n=102)

Variable	Frequency (%)
Sex	
Male	45 (44.1)
Female	57 (55.9)
Age (years), mean±SD	57.9±8.6
Adult (18–64 years)	75 (73.5)
Older adult (>64 years)	27 (26.5)
Educational level	
No formal education	5 (4.9)
Primary school	5 (4.9)
Junior high school	8 (7.8)
Senior high school	24 (23.5)
Diploma	13 (12.7)
Bachelor's degree	39 (38.2)
Postgraduate	8 (7.8)
Marital status	
Married	92 (90.2)
Divorced/unmarried	10 (9.8)
Employment status	
Employed	37 (36.3)
Unemployed	65 (63.7)
Physical activity	
Active	72 (70.6)
Inactive	30 (29.4)
Comorbidities	
Hypertension	30 (29.4)
Hypertension + dyslipidemia	15 (14.7)
Dyslipidemia	14 (13.7)
None	43 (42.2)
Duration of diabetes (years), median (min–max)	12.0 (1–24)
<5 years	11 (10.8)
5–10 years	32 (31.4)
>10 years	59 (57.8)
Diabetes treatment regimen	
Oral hypoglycemic agent (OHA) monotherapy	20 (19.6)
Combination of 2 OHA	11 (10.8)
Combination of 3 OHA	2 (2.0)
Basal insulin	16 (15.7)
Prandial insulin	4 (3.9)
OHA + basal insulin	36 (35.3)
OHA + prandial insulin	2 (2.0)
Basal + prandial insulin	5 (4.9)
OHA + basal + prandial insulin	2 (2.0)
2 OHA + prandial insulin	1 (1.0)
2 OHA + basal + prandial insulin	3 (2.9)
Body mass index (kg/m ²), median (min–max)	25.9 (18.4–38.8)
Underweight	1 (1.0)
Normal weight	20 (19.6)
Overweight	42 (41.2)
Obese	39 (38.2)
HbA1c (%), median (min–max)	8.65 (5.10–15.30)
<7%	13 (12.7)
7–8%	20 (19.6)
8–9%	23 (22.5)
>9%	46 (45.1)
Total Neuropathy Score (TNS), median (min–max)	10 (1–25)

Prevalence of depression and anxiety

The median PHQ-9 score was 4.5, reflecting overall minimal depressive symptoms; however, the prevalence of depression reached 50.0% (**Table 2**). The median GAD-7 score was 3.0, also within

the minimal range, with an anxiety prevalence of 33.3%, lower than that observed for depression (**Table 2**).

Table 2. Prevalence of depression and anxiety symptoms among patients with diabetic neuropathy

Depression and anxiety score	Frequency (%)
Patient Health Questionnaire-9 (PHQ-9) score, median (min–max)	4.5 (0–22)
Depression	51 (50.0)
No depression	51 (50.0)
Generalized Anxiety Disorder-7 (GAD-7) score, median (min–max)	3.0 (0–20)
Anxiety	34 (33.3)
No anxiety	68 (66.7)

Association of diabetic neuropathy severity with depression and anxiety

Patients with depression had significantly greater diabetic neuropathy severity than patients without depression, with median TNS scores of 11 (range: 1–25) and 8 (range: 1–21), respectively ($p=0.007$) (**Table 3**). Similarly, patients with anxiety had significantly higher TNS scores than patients without anxiety, with median scores of 10.5 (range: 2–25) and 9 (range: 1–21), respectively ($p=0.040$) (**Table 3**).

Table 3. Association of diabetic neuropathy severity with depression and anxiety

Variable	Total Neuropathy Score (TNS) Median (min–max)	p -value ^a
Depression		
Depression	11 (1–25)	0.007*
No depression	8 (1–21)	
Anxiety		
Anxiety	10.5 (2–25)	0.040*
No anxiety	9 (1–21)	

^a Analyzed using Mann–Whitney U test

* Statistically significant ($p<0.05$)

Correlations between diabetic neuropathy severity score and depression as well as anxiety scores are presented in **Table 4**. Neuropathy severity score had a weak positive correlation with depression severity score ($r=0.332$, $p<0.001$) and a weak positive correlation with anxiety severity score ($r=0.200$, $p=0.044$) (**Table 4**).

Table 4. Correlation of diabetic neuropathy severity with depression and anxiety scores

Variable	Total Neuropathy Score (TNS) Spearman's rho (r)	p -value ^a
Depression (PHQ-9 score)	0.332	<0.001*
Anxiety (GAD-7 score)	0.200	0.044*

GAD-7: Generalized Anxiety Disorder-7; PHQ-9: Patient Health Questionnaire-9

^a Analyzed using Spearman's correlation test

* Statistically significant ($p<0.05$)

Linear regression analysis demonstrated that diabetic neuropathy severity was significantly associated with depressive symptoms (**Table 5**). The regression coefficient (B: 0.230; $p=0.013$; $R^2=0.060$) indicates that each one-point increase in the TNS was associated with a 0.230-point increase in the PHQ-9 score. In contrast, neuropathy severity was not significantly associated with anxiety outcomes. Although a positive trend was observed (B: 0.129; $p=0.141$; $R^2=0.022$), indicating a 0.129-point increase in GAD-7 score per one-point increase in TNS, this association did not reach statistical significance.

Table 5. Linear regression between diabetic neuropathy severity, depression, and anxiety

Independent variable	Dependent variable	B	p -value ^a	R^2
Neuropathy severity (TNS score)	Depression (PHQ-9 score)	0.230	0.013*	0.060
Neuropathy severity (TNS score)	Anxiety (GAD-7 score)	0.129	0.141	0.022

GAD-7: Generalized Anxiety Disorder-7; PHQ-9: Patient Health Questionnaire-9; TNS: Total Neuropathy Score

^a Analyzed using linear regression

* Statistically significant ($p<0.05$)

Discussion

The present study demonstrated that patients with depression and anxiety had greater diabetic neuropathy severity than those without these conditions. Neuropathy severity showed a stronger association with depressive symptoms than with anxiety symptoms, with only the association with depression remaining significant in linear regression analysis. Each one-point increase in the TNS was associated with a 0.230-point increase in PHQ-9 score, suggesting that worsening neuropathic impairment contributes to a greater psychological burden. Although the proportion of explained variance was modest ($R^2=0.060$), the finding indicates that neuropathy severity represents an important clinical factor associated with depression in this population. In contrast, diabetic neuropathy severity was significantly associated with anxiety symptoms, yet lost significance after linear regression. While a positive trend was observed, with higher neuropathy scores corresponding to higher GAD-7 scores, the association did not reach statistical significance ($p=0.141$), and neuropathy severity explained only a small proportion of the variability in anxiety symptoms ($R^2=0.022$).

These findings are consistent with previous studies indicating that the relationship between clinical factors and depression in diabetes is driven more by disease severity than by the mere presence of complications. Severe comorbidity burden and advanced diabetic complications have been associated with higher rates of depression, whereas associations are often less consistent in patients with relatively stable disease. A study reported that greater cumulative comorbidity burden was a strong predictor of depression among patients with T2DM [18], while another study identified diabetic complications, including neuropathy, nephropathy, retinopathy, and diabetic foot ulcers, as significant contributors to depression risk [19].

Several mechanisms may explain the observed association between diabetic neuropathy and depression. Neuropathic pain is often chronic, persistent, and difficult to control, resulting in impaired mobility, reduced independence, sleep disturbance, and diminished quality of life [20]. As neuropathy progresses, patients may experience increasing functional limitations that interfere with daily activities and social participation [4]. A study reported that severe diabetic neuropathy is frequently accompanied by clinically significant depressive symptoms arising from chronic pain and physical disability [21]. Feelings of helplessness, frustration, and loss of autonomy may further contribute to the development of depressive symptoms [21].

The absence of a significant association between neuropathy severity and anxiety in the present study warrants consideration. Although previous studies have suggested that diabetic neuropathy may contribute to anxiety through fear of disease progression, recurrent pain, gait instability, and concerns regarding future disability, anxiety is a multifactorial condition influenced by a broader range of psychological, social, and environmental determinants [7–9]. Factors such as educational level, socioeconomic status, coping strategies, family support, and perceived disease control may have a greater influence on anxiety symptoms than neuropathy severity alone [22]. This interpretation is supported by the relatively small proportion of anxiety variance explained by neuropathy severity in the present study ($R^2=0.022$).

Diabetic neuropathy and depression share several common pathological pathways. Chronic hyperglycemia promotes oxidative stress, endothelial dysfunction, and persistent low-grade inflammation, resulting in elevated levels of pro-inflammatory cytokines that have also been implicated in the pathogenesis of depression [23]. Chronic pain further activates the hypothalamic–pituitary–adrenal axis, leading to prolonged cortisol exposure, impaired neuroplasticity, and alterations in neurotransmitter regulation [7,24]. These overlapping inflammatory and neuroendocrine mechanisms may explain why neuropathy severity showed a stronger relationship with depression than with anxiety.

Sleep disturbance may represent an additional pathway linking diabetic neuropathy to psychological distress [7]. A study demonstrated a significant correlation between neuropathy severity and impaired sleep quality. Nocturnal pain, paresthesia, and discomfort frequently disrupt sleep, which in turn impairs emotional regulation and increases vulnerability to depressive symptoms [25]. Poor sleep quality has been consistently associated with reduced resilience to chronic disease burden and may partially mediate the relationship between neuropathy and depression [7,25].

Depression has been associated with poor treatment adherence, reduced self-care behaviors, suboptimal glycemic control, and increased risk of diabetes-related complications [26]. Early recognition of depressive symptoms among patients with diabetic neuropathy may therefore facilitate more comprehensive management strategies that address both physical and psychological aspects of diabetes care. Routine screening for depression in patients with moderate-to-severe neuropathy may be particularly beneficial, given the significant association observed between neuropathy severity and depressive symptom burden in the present study.

This study has several limitations. The cross-sectional design precludes causal inference between diabetic neuropathy and psychological symptoms. Depression and anxiety were assessed using questionnaire-based instruments rather than structured psychiatric interviews, introducing the possibility of measurement bias. In addition, important factors such as neuropathic pain severity, sleep quality, social support, and quality of life were not evaluated and may have influenced the observed associations. The relatively low R^2 values further suggest that other biological, psychological, and social factors contribute to depression and anxiety in patients with T2DM. Future longitudinal studies are needed to clarify the temporal relationship between diabetic neuropathy and psychological disorders. Larger multicenter studies may improve generalizability, while investigations incorporating neuropathic pain, sleep disturbance, inflammatory biomarkers, and psychosocial factors may provide a more comprehensive understanding of the mechanisms linking diabetic neuropathy with depression and anxiety.

Conclusion

Greater diabetic neuropathy severity was associated with depressive symptoms, whereas its association with anxiety symptoms was weaker and did not remain significant in linear regression analysis. These findings suggest that worsening neuropathic involvement may contribute to the psychological burden experienced by patients with T2DM, particularly in relation to depression. However, the modest effect size indicates that depression and anxiety are likely influenced by multiple biological, psychological, and social factors beyond neuropathy alone. Routine assessment of psychological well-being in patients with diabetic neuropathy may facilitate a more comprehensive approach to diabetes care.

Ethics approval

Protocol of the present study was reviewed and approved by Ethical Committee for Health Research, Dr. Zainoel Abidin Hospital, Banda Aceh, Indonesia (Approval number: 310/ETIK-RSUDZA/2025).

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Competing interests

All the authors declare that there are no conflicts of interest.

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Underlying data

Derived data supporting the findings of this study are available from the corresponding author on request.

Declaration of artificial intelligence use

An artificial intelligence (AI)-based language model, ChatGPT, was used for language refinement (improving grammar, sentence structure, and readability of the manuscript). We confirm that all

AI-assisted processes were critically reviewed by the authors to ensure the integrity and reliability of the results. The final decisions and interpretations presented in this article were solely made by the authors.

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