Quality of life in older adults with diabetic peripheral neuropathy: International Classification of Functioning, Disability and Health (ICF) framework

Qualidade de vida em idosos com neuropatia periférica diabética: Classificação Internacional de Funcionalidade, Incapacidade e Saúde (CIF)

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Abstract

Introduction: The decrease in quality of life (QoL) in individuals with diabetic peripheral neuropathy (DPN) is still debated, with differing opinions on its root causes. **Objective:** To investigate the factors contributing to this decline by applying the International Classification of Functioning, Disability and Health (ICF) framework. **Methods:** A cross-sectional study was conducted involving 242 older adults with type 2 diabetes mellitus from the community of Sukoharjo. This study was divided into two groups: those with DPN and those without DPN, which were identified through the physical test of the Michigan Neuropathy Screening Instrument. Another variable was observed, including QoL, age, body mass index, gender, blood pressure, hypertension status, hemoglobin, visual function, fear of falling, duration, neuropathy pain, falls history, lower extremity muscle strength, cognition, depression, cardiovascular endurance, and balance. The statistical analysis used the comparison test and multiple linear regression. **Results:** Multiple linear regression analysis showed cognitive function was most significantly associated with QoL in DPN group (B = 0.296, SE = 0.136, p = 0.032), followed by visual function (B = -0.150, SE = 0.051, p = 0.004) and static balance (B = 0.140, SE = 0.061, p = 0.024). While in the non-DPN group, the falls history was interpreted as the strongest factor influencing QoL (B = -4.691, SE = 1.454, p = 0.002) and also associated with duration of diabetes mellitus (B = -0.915, SE = 0.302, p = 0.003). **Conclusion:** Based on the ICF framework, sensory deficits, especially in vision, may worsen functional limits and lower QoL in DPN. Targeted treatment of visual and balance issues could help improve outcomes.

Keywords: Diabetic neuropathies. International Classification of Functioning, Disability and Health. Quality of life.

Resumo

Introdução: *A diminuição da qualidade de vida (QV) em indivíduos com neuropatia periférica diabética (NPD) ainda é debatida, com opiniões divergentes sobre suas causas.* ***Objetivo:*** *Investigar os fatores que contribuem para essa diminuição, aplicando a Classificação Internacional de Funcionalidade, Incapacidade e Saúde (CIF).* ***Métodos:*** *Realizou-se um estudo transversal com 242 idosos com diabetes mellitus tipo 2 da comunidade de Sukoharjo. Os participantes foram divididos em dois grupos: com NPD e sem NPD, identificados por meio do teste físico do Michigan Neuropathy Screening Instrument. Foram observadas outras variáveis, incluindo QV, idade, índice de massa corporal, sexo, pressão arterial, presença de hipertensão, hemoglobina, função visual, medo de quedas, duração da doença, dor neuropática, histórico de quedas, força muscular dos membros inferiores, cognição, depressão, resistência cardiovascular e equilíbrio. A análise estatística utilizou o teste de comparação múltipla e regressão linear múltipla.* ***Resultados:*** *A análise de regressão linear múltipla mostrou que a função cognitiva foi o fator mais significativamente associado à qualidade de vida no grupo com neuropatia diabética periférica (NDP) (B = 0,296, SE = 0,136, p = 0,032), seguida pela função visual (B = -0,150, SE = 0,051, p = 0,004) e pelo equilíbrio estático (B = 0,140, SE = 0,061, p = 0,024). Já no grupo sem NDP, o histórico de quedas foi interpretado como o fator mais forte que influencia a qualidade de vida (B = -4,691, SE = 1,454, p = 0,002) e também associado à duração do diabetes mellitus (B = -0,915, SE = 0,302, p = 0,003).* ***Conclusão:*** *Com base na estrutura da CIF, os déficits sensoriais, especialmente na visão, podem agravar as limitações funcionais e diminuir a qualidade de vida na NDP. O tratamento direcionado aos problemas visuais e de equilíbrio pode contribuir para a melhoria dos resultados.*

Palavras-chave: *Neuropatias diabéticas. Classificação Internacional de Funcionalidade, Incapacidade e Saúde. Qualidade de vida.*

Introduction

Diabetes mellitus (DM) is a common metabolic condition that affects the ability to regulate blood glucose levels.[1] In particular, type 2 diabetes mellitus (T2DM) is known to be directly related to lifestyle factors and is becoming a major health problem due to various complications.[2]

Microvascular complications in T2DM refer to damage to small blood vessels caused by prolonged high blood sugar levels.[3] Diabetic peripheral neuropathy (DPN) is the most common complication that reduces proprioception function, occurring in 60-70% of chronic T2DM.[4,5] DPN impairs movement by reducing touch, temperature, pain perception, and proprioception, leading to poor foot position sense, balance problems, walking difficulties, and falls.[6] Other common complications of T2DM are diabetic retinopathy and vestibular dysfunction, which are reported to increase the risk of falls and a lack of quality of life (QoL).[4]

DPN is a serious complication of DM that involves some complex pathophysiologic mechanisms. The main factor that triggers the development of this condition is poor glycemic control.[7] Even if blood sugar levels are well managed, neuropathy can still occur through other mechanisms.[8] Key metabolic pathways, polyol, hexosamine, and protein kinase C promote oxidative stress and nerve damage. This is worsened by chronic inflammation and elevated reactive oxygen species.[9] On the other hand, patients with DPN more than 5 years have up to 6.9 times the potential to experience poorer QoL than those with less than 5 years.[10] However, some findings suggest that the relationship between DPN duration and QoL is not always linear.

Furthermore, aging and elevated body mass index (BMI) are linked to reduced sensorimotor function, fall risk, and aggravated DPN symptoms. Psychological resilience and sufficient body mass may serve as protective factors in certain individuals.[11] Then, female is often reported to have a lower QoL due to higher pain perception, and other feeling of neuropathy such as numbness, tingling, burning sensation, stabbing, painful cramps and muscle weakness for mobility that increase anxiety.[12] Worsening pain and discomfort at night can lead to poor sleep quality and insomnia, compounding the overall impact on one's health and well-being.[13]

Meanwhile, hypertension can accelerate vascular damage and worsen neuropathy, though controlled blood pressure may support tissue perfusion.[14] Additionally, low hemoglobin impairs nerve oxygenation and raises cardiac strain, while poor vision heightens fall risk and reduces QoL.[15]

In diabetic neuropathy, the progressive damage to peripheral nerves leads to impaired motor nerve conduction and muscle weakness. Loss of nerve supply reduces muscle activation, resulting in atrophy, particularly

in the distal muscles of the lower limbs. This weakness limits mobility, decreases stability, and contributes to difficulties in performing daily activities,[15] and reduced physical activity.[16]

QoL has been recognized by the World Health Organization as a fundamental indicator of human well-being, including for individuals living with DPN. In alignment, the International Classification of Functioning, Disability and Health (ICF) framework highlights that body structures and functions, personal characteristics, and environmental influences shape QoL. Through this framework, determinants of QoL in DPN can be examined more comprehensively by integrating biomedical, functional, and contextual dimensions.

Evidence from previous studies demonstrates varied perspectives regarding QoL in individuals with DPN. A systematic review found that longer disease duration contributes to the progression of neuropathic pain, subsequently impairing QoL.[17] While some studies identify neuropathic pain as the primary factor responsible for reduced QoL, others indicate that additional variables, such as blood glucose levels, age, and anxiety, also play a significant role in worsening QoL within this population.[8] Therefore, this study aimed to explore the determinants influencing the QoL in patients with T2DM and DPN through the application of the ICF framework.

Methods

This research employed a cross-sectional survey design to investigate the predictors of QoL among older adults with and without DPN residing in Sukoharjo City, Central Java, Indonesia. The research protocol was approved by the Health Research Ethics Committee of Dr. Moewardi Hospital with approval number 2.204/IX/HR EC/2024.

Participants were aged 60 years or older. Recruitment was conducted through enrollment in the Ministry of Health's Chronic Disease Management Program (Prolanis). The total number of participants required for this study was 242, comprising 121 individuals with DPN and 121 individuals without DPN, with the following calculations: p = 7.1 %, z-score = 1.96, precision value (d) = 0.05 and proportion value (q) = 1-0.071, which is 0.092.[18] To anticipate potential dropouts, an additional 10% of participants were included, resulting in a total of 121 respondents per group.

The inclusion criteria included a diagnosis of T2DM for 5 years or more, and no macrovascular complications such as stroke, coronary heart disease, or peripheral arterial disease. While the exclusions were central nervous system disorders such as cerebral ataxia and Parkinson's disease, inability to walk independently despite using assistive devices, psychiatric disorders, disabilities in the lower extremities that interfere with standing and walking mobility, patients with injuries so that they are unable to stand and walk independently, inability to communicate well, and postoperative patients.

Research instrument

Personal factor: The personal data consisted of age, gender (female/male), BMI (kg/m^2), hypertension status (yes/no), serum Hemoglobin A1c - HbA1c (%), visual function (normal/low), sleep duration (hours/day), fall anxiety (Fall Efficacy Scale-International - FES-I score) and history of falls. Impairments included lower limb muscle strength (mea-sured in seconds), cognitive function (as assessed by the Montreal Cognitive Assessment – MoCA score), and depression (as measured by the Geriatric Depression Short-Form Scale - GDS score). Activity limitations were recorded in terms of physical fitness using the Two Minute Walk Test (in meters), static balance (in seconds), and dynamic balance (in seconds). Blood sugar levels were measured using HbA1c, a laboratory parameter that indicates the average blood sugar level over the past 2-3 months. It measures the percentage of haemoglobin in the blood that is bound to glucose. HbA1c is a more stable and accurate indicator of blood sugar control than a fasting blood sugar test, whereas values of 6.5% or above are used to diagnose DM.[18] A certified medical laboratory technician collected blood samples from a forearm vein using standard venipuncture procedures. The samples were placed into collection tubes and maintained at 4°C to ensure sample integrity. Sub-sequent analysis was performed at the integrated labo-ratory of Muhammadiyah University of Surakarta.

Impairments: The cognitive level was assessed using the Indonesian version of the MoCA (MoCA-Ina), a highly reliable and valid tool for screening cognitive impairment.[19] The instrument had a total score of 30. Scores between 18 and 25 indicate mild cognitive impairment, 10 to 17 indicate moderate impairment, and below 10 reflect severe cognitive impairment.[20] Depression was diagnosed using the Indonesian version of the Geriatric

Depression Scale, with a score of more than 5 indicating depression.[21] The five-time sit-to-stand test (5xSST) was used to examine the strength of the muscles in the lower extremities in seconds, with the cut-off no more than 15 seconds.[22] The Indonesian version of the FES-I, with 16 questions,[23] has a total score range from 16 to 64, where 16 indicates no fear of falling, and 64 reflects a high level of concern about falling.[24]

Activity limitations: The 2-minute walking test was used to assess cardiovascular endurance. Participants completed a 2-minute walk test, during which they could pause if needed. The distance walked (meters) was recorded as a measure of cardiovascular endurance, with greater distances indicating higher endurance.[25] The Modified Clinical Test of Sensory Interaction on Balance (mCTSIB) assessed static balance for 30 seconds under each of four conditions: standing on a firm surface with eyes open; standing on a firm surface with eyes closed; standing on foam with eyes open; and standing on foam with eyes closed. Participants stood with arms crossed and feet together; in eyes-closed conditions, the test was failed if they stepped, moved arms, leaned, or lost posture.[26] Timed up-and-go (TUG) tests can reveal functional mobility limitations. Subjects were required to begin sitting in a chair, rise, walk straight for three meters, turn, and then walk straight back to sit; no more than 13.5 seconds was con-sidered a good performance.[27]

Quality of life

The Indonesian version of the World Health Organization Quality of Life – BREF (WHOQoL-BREF) is a valid and reliable instrument to assess QoL.[28] It contains 26 items and addresses four QoL domains, with each domain scored on a scale from 0 to 100: physical health (7 items), psychological health (6 items), social relationships (3 items), and environment (8 items). Two other items measure overall QoL and general health.[29]

Statistical analysis

Data were analyzed using SPSS version 23.0 (IBM, Armonk, NY, USA). Descriptive statistics summarized continuous variables as mean ± standard deviation, and categorical variables as frequency and percentage, categorising all variables according to the ICF framework. Normality was assessed using the Kolmogorov-Smirnov test, confirming an approximately normal distribution.

Group differences were examined using the t-test, while Spearman's rank correlation identified variables associated with QoL for inclusion in model development. A multivariate linear regression (enter method) was performed to construct a predictive model, with assumptions of multivariate normality and multicollinearity tested for both groups. Statistical significance level $\alpha = 0.05$ (two-tailed).

Results

There were significant differences between the two groups in systolic and diastolic blood pressure, fear of falling, duration of DM, neuropathy pain, and fall history. The DPN group revealed a higher number of patients with hypertension status, fear of falling, and mostly the patients had moderate neuropathy pain than those without DPN. The number of patients with hypertension in DPN group was twice that group without DPN (Table 1).

Table 1 - Personal factors of older adults with (n = 121) and without (n = 121) diabetic peripheral neuropathy (DPN)

Personal factors	With DPN	Without DPN	p-value
Age (years)	63.63 ± 63.35	62.21 ± 65.64	0.088
HbA1C	8.10 ± 1.90	8.70 ± 5.70	0.672
BMI	24.46 ± 2 .70	24.28 ± 3.10	0.760
Gender			
Male	48 (39.7)	51 (42.1)	0.708
Female	73 (60.3)	48 (57.9)	
Blood pressure			
Systolic	140.3 ± 17.59	130.8 ± 16.05	<0.001*
Diastolic	86.61 ± 10.82	81.61 ± 10.12	<0.001*
Hypertension			
Yes	71 (58.7)	35 (28.9)	1.000
No	50 (41.3)	86 (71.1)	
VF (scores)	64.75 ± 21.40	57.72 ± 28.88	0.460
FoF (scores)	5.24 ± 1.97	4.72 ± 2.25	0.045*
Duration (scores)	9.43 ± 3.37	6.52 ± 3.06	<0.001*
FH (ascores)	1.21 ± 0.77	0.84 ± 0.64	<0.001*

Note: Data presented as mean ± standard deviation, except for gender and hypertension status: n (%). HbA1C = glycated hemoglobin (%); BMI = body mass index (kg/m^2); VF = visual function; FoF = fear of falling; FH = fall history. *Significant.

Table 2 shows that the DPN group had lower muscle strength of the lower extremity, static and dynamic balance, and also a higher number of patients with depression. Before performing multiple linear regression analysis, a correlation test was first conducted between the QoL variable and the covariates. Subsequently, variables with $p < 0.05$ were included in the linear regression analysis in groups with and without DPN (Table 3).

Cognitive function emerged as the strongest predictor of QoL ($p = 0.032$), exerting an influence twice as great as visual function ($p = 0.004$) and static balance ($p = 0.024$) (Table 4). In contrast, among participants without DPN, fall history showed a stronger negative association with quality of life than diabetes duration, with a coefficient magnitude approximately 5.13 times greater (Table 5).

Table 2 - Factors classified according to the International Classification of Functioning, Disability and Health model among older adults with (n = 121) and without (n = 121) diabetic peripheral neuropathy (DPN)

Variables	With DPN	Without DPN	p-value
Impairments			
Neuropathy pain (score)	5.66 ± 1.81	3.85 ± 2.45	<0.001*
LE muscles strength (5xSTS)	15.90 ± 3.29	15.47 ± 3.53	0.050*
Cognition (MOCA-Ina scores)	19.53 ± 5.36	18.82 ± 5.22	0.251
Depression (GDS-Ina scores)	5.24 ± 1.91	4.77 ± 2.25	0.045
Activity limitations			
Cardiovascular endurance (2MWT)	128.70 ± 45.40	129.60 ± 40.30	0.708
Static balance (m-CTSIB)	81.91 ± 14.7	86.30 ± 2.61	0.016
Dynamic balance (TUG)	15.01 ± 2.81	13.96 ± 2.61	0.001
Quality of life			
WHOQOL-BREF (scores)	68.80 ± 8.90	69.10 ± 9.10	0.927
Physical domain	47.20 ± 11.10	47.50 ± 10.90	0.787
Social domain	47.60 ± 9.90	48.20 ± 11.20	0.650
Functional domain	55.70 ± 12.40	53.40 ± 10.90	0.101
Emotional domain	42.90 ± 11.50	45.30 ± 12.60	0.168

Note: DPN = diabetic peripheral neuropahy; LE = lower extremity; 5xSTS = Five Times Sit to Stand Test (seconds); MOCA-Ina = Montreal Cognitive Assessment Indonesian version; GDS-Ina = Geriatric Depression Scale Indonesian version; 2MWT = 2 minutes walking test; mCTSIB = Modified Clinical Test of Sensory Interaction in Balance; TUG = Timed Up and Go Test; WHOQOL-BREF = World Health Organization Quality of Life – BREF. Data presented as mean ± standard deviation. *Significant.

Table 3 - Correlation analysis among World Health Organization Quality of Life (WHOQoL) and co-variables in older adults with (n = 121) and without (n = 121) diabetic peripheral neuropathy (DPN)

Variables	With DPN	Without DPN
Personal factor		
Age (years)	0.442	0.746
Gender	0.973	0.139
Serum hemoglobin HbA1C (mg/dl)	0.452	0.025*
Body mass index (kg/m^2)	0.106	0.047*
Blood pressure systolic (mmHg)	0.581	0.522
Blood pressure diastolic (mmHg)	0.825	0.629

Table 3 - Correlation analysis among World Health Organization Quality of Life (WHOQoL) and co-variables in older adults with (n = 121) and without (n = 121) diabetic peripheral neuropathy (DPN) (continued)

Variables	With DPN	Without DPN
Personal factor		
Hypertension status	0.367	0.887
Visual function (scores)	0.003*	0.002*
Falls efficacy (scores)	0.053	0.673
Duration of diabetes mellitus (years)	0.072	<0.001*
Falls history (numbers)	<0.001*	<0.001*
Impairments		
Neuropathic pain (NRS)	0.995	<0.001*
LE muscle strength (5xSTS)	<0.001*	<0.001*
Cognition (MOCA-Ina)	0.029	0.428
Depression (GDS-Ina)	0.031*	<0.001*
Activity limitation		
Cardiovascular endurance (2MWT)	0.009*	0.014*
Static balance (mCTSIB)	0.005*	0.015*
Dynamic balance (TUG)	<0.001*	<0.001*

Note: NRS = Numeric Rating Scale; DPN = diabetic peripheral neuropathy; HbA1C = glycated hemoglobin; Numeric Rating Scale; LE = lower extremity; 5xSTS = Five Times Sit to Stand Test; MOCA-Ina = Montreal Cognitive Assessment Indonesian version; GDS-Ina = Geriatric Depression Scale Indonesian version; 2MWT = 2 minutes walking test; mCTSIB: Modified Clinical Test of Sensory Interaction in Balance; TUG = Timed Up and Go Test. Data presented as p-value. *Significant.

Table 4 - Multiple linear regression analysis of the variables quality of life of older adults with diabetic peripheral neuropathy (n = 121)

Variables	B	SE	Beta	t	p
Constant	74.467	9.067	-	8.213	<0.001*
Personal factors					
Visual function (score)	-0.150	0.051	-0.360	-2.962	0.004*
Serum hemoglobin HbA1C (mg/dl)	0.045	0.395	0.010	0.114	0.909
Falls history (number)	-1.228	1.024	-0.107	-1.200	0.233
Impairments					
LE muscle strength (5XSTS)	-0.211	0.228	-.0780	-0.925	0.357
Cognitive (MOCA-Ina)	0.296	0.136	0.177	2.177	0.032*
Depression (GDS-Ina)	-0.057	0.372	-0.012	-0.152	0.879
Activity limitation					
Cardiovascular endurance (2 MWT)	-0.021	0.018	-0.105	-1.157	0.250
Static balance (mCTSIB)	0.140	0.061	0.232	2.292	0.024*
Dynamic balance (TUG)	-0.388	0.326	-0.122	-1.191	0.236

Note: HbA1C = glycated hemoglobin; LE = lower extremity; 5XSTS = The Five Time Sit to Stand test; MOCA-Ina = Montreal Cognitive Assessment Indonesian version; GDS-Ina = Geriatric Depression Scale Indonesian version; 2MWT = 2 minutes walking test; mCTSIB: Modified Clinical Test of Sensory Interaction in Balance; TUG = Timed Up and Go Test; NRS = Numeric Rating Scale; GDS = Geriatric Depression Scale. *Significant.

Table 5 - Multiple linear regression analysis of the variables quality of life of older adults without diabetic peripheral neuropathy (n = 121)

Variables	B	SE	Beta	t	p
Constant	87.331	7.200	-	12.129	<0.001*
Personal factors					
Visual function (score)	0.005	0.051	0.017	0.107	0.915
Duration of diabetes mellitus (years)	-0.915	0.302	-0.308	-3.033	0.003*
Falls history (number)	-4.691	1.454	-0.333	-3.225	0.002*
Impairments					
Neuropathy pain (NRS)	0.019	0.510	0.005	0.038	0.970
LE muscle strength (5XSTS)	0.051	0.204	0.020	0.248	0.804
Depression (GDS-Ina)	-0.458	0.326	-0.113	-1.402	0.164
Activity limitation					
Cardiovascular endurance (2 MWT)	-0.021	0.019	-0.092	-1.111	0.269
Static balance (mCTSIB)	-0.008	0.055	-0.012	-0.141	0.888
Dynamic balance (TUG)	-0.281	0.291	-0.081	-0.966	0.336

Note: HbA1C = glycated hemoglobin; LE = lower extremity; 5XSTS = The Five Time Sit to Stand test; MOCA-Ina = Montreal Cognitive Assessment Indonesian version; GDS-Ina = Geriatric Depression Scale Indonesian version; 2MWT = 2 minutes walking test; mCTSIB: Modified Clinical Test of Sensory Interaction in Balance; TUG = Timed Up and Go Test; NRS = Numeric Rating Scale; GDS = Geriatric Depression Scale. *Significant.

Discussion

The results of this study showed that in the group of patients with DPN, visual function and static balance had the most significant contribution to the decline in QoL. This finding is in line with the ICF framework, which emphasizes the importance of impairments and activity limitations in determining individual function and participation.[30] This study found elevated serum hemoglobin levels across all groups. Previous evidence suggests that higher hemoglobin levels in diabetes may contribute to oxidative stress and vascular dysfunction, which are central mechanisms driving diabetic peripheral neuropathy that lead to endothelial damage, impaired vascular regulation, reduced nerve perfusion, and ultimately the development of DPN symptoms such as sensory loss, pain, and motor deficits.[31] While these findings support existing mechanistic pathways, the cross-sectional design limits causal interpretation. Even so, the results highlight the potential value of monitoring hemoglobin levels in diabetes management. Future longitudinal or experimental studies are needed to confirm these relationships and explore whether modifying hemoglobin-related mechanisms could help prevent or slow the progression of DPN.

The DPN group exhibited higher levels of neuropathic pain, depression, reduced lower-extremity muscle strength, and poorer static and dynamic balance. These interconnected factors may collectively contribute to greater functional decline and mobility limitations in individuals with diabetic neuropathy. Despite these differences, no significant variation in overall QoL or its specific domains was observed between groups. This lack of difference may be explained by the influence of shared factors, such as comorbidities, psychological status, and functional impairments that affect both groups similarly. It is also possible that individuals with neuropathic pain have developed coping strategies or benefited from effective pain management, thereby reducing the impact of pain on their perceived QoL.

The reduction in QoL among individuals with DPN appears to be strongly influenced by impairment-related factors, particularly cognitive dysfunction, and further compounded by visual decline and reduced static balance capacity (Tables 4 and 5). This study reported that better cognitive and balance function was associated with higher QoL, and reduced visual ability corresponds to a decline in QoL. Some studies mentioned that cognitive function plays a significant role in determining the QoL in patients with neuropathic pain.[32]

Previous research supports the role of cognitive impairment in worsening pain perception, limiting daily activities, and increasing emotional distress.[33] Conversely, preserved cognitive function may enhance self-management strategies, treatment adherence, and social participation, thereby mitigating the negative impact of neuropathic pain on QoL in DPN patients.[34] These findings highlight the importance of incorporating cognitive assessment and intervention into comprehensive care for patients with DPN.

Furthermore, impaired vision reduces the ability to accurately perceive environmental cues necessary for maintaining postural stability, increasing the risk of imbalance and falls. In individuals with neuropathic pain, sensory impairments in the lower extremities further exacerbate balance disturbances. Impaired static balance can restrict mobility, diminish confidence in daily activities, and lead to social withdrawal, collectively impairing overall QoL.[35] Consequently, preserving optimal visual function is crucial for enhancing balance and maintaining functional independence in this population.

On the other hand, in patients without DPN, the decline in QoL tended to be influenced by personal factors, particularly history of falls and the longer duration of diabetes, which indicates that those who have had diabetes for a longer period tend to report more falls, which may subsequently lead to reduced QoL. Even in the absence of neuropathic pain, prolonged disease may lead to fatigue, reduced physical capacity, and increased treatment burden. Microvascular complications, including retinopathy, nephropathy, and neuropathy, typically appear after 5–10 years in type 1 diabetes, whereas they are often already present at diagnosis in T2DM due to years of silent progression.[34] Macrovascular conditions, such as coronary artery disease and stroke, usually develop later, particularly with poor glycemic control.[36] These cumulative challenges can restrict daily function, increase psychological distress, and reduce social engagement, ultimately lowering QoL.[37] Therefore, early intervention and sustained long-term management are essential to support well-being in individuals with longstanding diabetes.

Individuals with T2DM are at an increased risk of falling, and this risk becomes even higher among those with recurrent fall episodes. In patients with DPN, sensory loss, pain, and impaired proprioception contribute to gait instability and balance dysfunction, making repeated falls more likely. This vulnerability is further intensified by visual impairment, muscle weakness, and autonomic dysfunction, which may lead to dizziness or postural hypotension. The psychological consequences, particularly fear of falling, can reduce physical activity and endurance, resulting in muscle deconditioning and further increasing the likelihood of subsequent falls.[38] This cycle of recurrent falls not only increases the likelihood of injuries and fractures but also significantly diminishes independence and QoL in patients with DM.[39] Additionally, this condition is also a concern among patients without DPN, as experiencing falls heightens fear and adversely affects their mental health.

Whether or not patients have DPN, the consequences of falling, particularly recurrent falls, are similar. Fear of falling can reduce mobility and limit engagement in daily activities, further affecting overall functioning.[40] A history of falls is a key predictor of reduced QoL, highlighting the importance of fall prevention in T2DM. QoL remains a crucial outcome in patients with and without neuropathic pain, as diabetes affects physical, emotional, and social functioning.

Although this study identified cognitive function as an important contributor to QoL in patients with neuropathic pain, it did not examine which specific cognitive domains are most affected. Nonetheless, applying the ICF framework helps identify factors linked to QoL decline and supports the development of targeted interventions for individuals with T2DM.

Conclusion

Based on the ICF framework, sensory deficits, especially in vision, may worsen functional limits and lower QoL in DPN. Targeted treatment of visual and balance issues could help improve outcomes.

Considering the proposed relationship between exercise modification, cognitive function, balance control, and QoL in individuals with DPN, further longitudinal or experimental research is required to confirm this hypothesis. Such studies would clarify whether integrated approaches, including structured exercise, medical and nutritional management, psychological support, and environmental adaptations, can effectively reduce fall risk and improve QoL in both individuals with and without DPN.

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Authors' contributions

OF conceptualized and designed the study, coordinated and conducted all research activities, collected and analyzed the data, interpreted the findings, and drafted the manuscript. DRK contributed to the study design, assisted in data interpretation, and critically revised the manuscript for important intellectual content. UBR contributed to the interpretation of the findings and critically reviewed the manuscript for intellectual content. All authors approved the final version of the manuscript.

Data availability statement

The data that support the findings of this study are available upon reasonable request.

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