ORIGINAL RESEARCH ARTICLE

Prevalence And Determinants of Peripheral Neuropathy Among Diabetes Mellitus Patients in a Rural Area of Salem District, Tamil Nadu

Shini Preetha Nirmalson[1], Vijayakarthikeyan M[2*], MD Thenmozhi[3]

[1,2]Department of Community Medicine, Vinayaka Mission's Kirupananda Variyar Medical College and Hospitals, Salem, Affiliated to Vinayaka Missions Research Foundation (VMRF) deemed to be University, Salem, India
[3]Department of Plastic Surgery, Government Mohan Kumaramangalam Medical College and Hospital, Salem, Affiliated to The Tamil Nadu Dr. M.G.R. Medical University, Salem, India

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ABSTRACT

Background: One of the most prevalent side effects of diabetes mellitus is diabetic peripheral neuropathy (DPN), affecting half of them. Early detection and treatment of DPN are essential in rural areas with limited access to healthcare. The objectives of the study are twofold: first, to estimate the prevalence of peripheral neuropathy among diabetes mellitus patients, and second, to identify the variables that influence the development of peripheral neuropathy.

Materials and Methods: It is a community based cross-sectional analytical study with 350 samples chosen by simple random sampling method. Michigan Neuropathy Screening Instrument (MNSI) history and physical examination version was used to evaluate DPN, and Biothesiometer findings were used to score the severity of DPN. Data analysis was done with SPSS Version 22.

Results: DPN was present in 22.1% (MNSI history) and 38.6% (MNSI physical exam) of samples. Biothesiometer testing showed mild, moderate, and severe DPN in 16.5%, 9.5%, and 12.6%, respectively. Male gender, diabetes duration >5 years, uncontrolled blood sugar, and hypertension were significant risk factors.

Conclusion: Regular screening of DPN at the time of diagnosis and follow up must be undertaken as a routine practice to be integrated in the health system. Diabetic individuals must be urged to inculcate foot care and other self-care practices as a routine habit.

Keywords: MNSI, Pain, DPN, Hyperglycemia

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***Correspondence:** Dr. Vijayakarthikeyan M (Email: vijay.doc09@gmail.com)

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INTRODUCTION

Globally, diabetic affects approximately 463 million with 77 million cases in India. Important micro vascular complication faced by the diabetics is diabetic neuropathy.[1] Presence of signs and symptoms of peripheral nerve dysfunction among diabetics after excluding other causes is defined as Diabetic Peripheral Neuropathy (DPN). About 50% of the diabetics are affected by peripheral neuropathy during their lifetime.[2] Two major types of diabetic neuropathy include Autonomic neuropathy and Diffuse neuropathy. Distal Symmetric Poly Neuropathy (DSPN) is a form of diffuse neuropathy and accounts for almost 75% of diabetic neuropathy.[3,4]

Diagnosis of peripheral neuropathy can be made by clinical symptoms and quantitative testing even in individuals who are asymptomatic. Among adult diabetics, the peripheral neuropathy prevalence varies 6% to 51% across the world.[5] Prevalence is higher among older diabetics, smokers, longer duration of diabetes, female sex, obesity, hypertension, poor glycemic control and type of diabetes (Type 1 vs Type 2).[6]

Individuals with peripheral neuropathy might have a mix of positive and negative symptoms involving sensory and motor system with some presenting without any symptoms. Positive symptoms are Paresthesia, pain, cramps and fasciculation. Common negative symptoms are numbness, postural instability, reduced or absent sensation, motor weakness and impaired balance.[7,8] Foot ulcers occur in a significant proportion of diabetic patients with neuropathy, leading to severe complications. The risk of limb amputation is 20 to 30 times higher in diabetics compared to non-diabetics, emphasizing the need for early detection and preventive care. Sleep disturbances are noted in those with severe neuropathic pain during nighttime.[9] Poor quality of life, depressive symptoms, reduced daily activities, social dysfunction and fall are some of the outcomes of decreased sensation and neuropathic pain.[10]

Main focus of management is on the strict glycemic control, proper foot care and pain management. Lifestyle management like regular physical activity, weight reduction and dietary changes plays a pivotal role.[6] Foot ulcers are the most preventable complications of diabetes mellitus and accounts for 40% of the total cost of diabetes in developing countries and 15% in developed countries.[11] Foot ulcers and amputation can be prevented by improving the awareness towards foot care through educational and foot care strategies.[12]

In Tamil Nadu, DPN poses a significant public health challenge, with high amputation rates due to delayed diagnosis. Despite its impact, limited studies have been conducted in this region. This study aims to assess the burden and management of DPN in Tamil Nadu, contributing to improved prevention and intervention strategies.

METHODOLOGY

Study design and study setting: It is a community based cross-sectional, analytical study conducted in the rural field practice area (Ellampillai) of a Tertiary Care Hospital in Salem district of Tamil Nadu.

Study Population: The study population consists of diabetes mellitus patients registered under the block primary health center, Ellampillai. The study was carried out for a period of 12 months (November 2023 – October 2024) from the day of approval from the Institutional ethical committee.

Inclusion and Exclusion Criteria: All registered patients with Type 1 and Type 2 diabetes mellitus aged ≥ 30 years were included in the study. Patients with Tubercular neuropathy, drug induced neuropathy and Vitamin B1, B2, B6, foliate deficiency neuropathic patients were excluded in this study.

Sample Size Calculation and sampling method: Sample size was calculated based on a previous study conducted by Baxi H et al in New Delhi in the year 2020. The prevalence of Diabetic neuropathy among diabetic individuals was found to be 28.85% and this was taken as the reference value for the sample size calculation for this study.[13] Using OpenEpi software, with a population size of 1993, the required sample size was determined to be 273. Adding a 10% non-response rate, the final target sample size was rounded to 300, but 350 participants were included to enhance statistical power. As per the records available in the primary health centre there are 1993 registered diabetes mellitus patients and they formed the sampling frame for this study. Samples were chosen by Simple random sampling method using computer generated random numbers.

Methods of data Collection: Data was collected using a pre tested semi-structured questionnaire. The questionnaire consisted of the Socio-demographic characteristics of the study population, Modified BG Prasad scale 2024 was used to classify the socioeconomic status of the study participants. Diabetes mellitus related characteristics, Risk factor related to diabetes mellitus Michigan Neuropathy Screening Instrument (MNSI) both history (15 item) and physical examination (Appearance of feet, ulceration, ankle reflex, vibration perception at great toe and monofilament test), Biothesiometer Findings on both the feet.

1. MNSI:[14]

History version: It consists of 15 Yes or No type of questions related to foot sensations. Responses of "yes" to items 1-3, 5-6, 8-9, 11-12, 14-15 are each counted as one point and A "no" response on items 7 and 13 counts as 1 point. Item #4 is a measure of impaired circulation and item #10 is a measure of general anesthesia and they are not included in scoring. A score of ≥7 out of 13 points in the 15-item questionnaire was taken as positive for the DPN.

Physical examination version: The second part of the MNSI is a brief physical examination involving Inspection of the feet (for deformities, dry skin, hair or nail abnormalities, callous or infection), assessment of vibration sensation at the dorsum of the great toe, grading of ankle reflexes and monofilament testing. A mean score of ≥ 2.5 out of 10 from the 5-item questionnaire was considered positive for DPN.

2. Biothesiometer:[15]

Biothesiometer grading of DPN is done by measuring the Vibration Perception Threshold (VPT) at 6 specific points on both the feet (Plantar aspect of the tip of first toe base of first, third and fifth toe, medial aspect of mod foot and heel). Based on the VPT, the individuals can be graded as: 1) Mild diabetic peripheral neuropathy: 20 mV-24 mV; 2) Moderate diabetic peripheral neuropathy: 25 mV – 39 mV, and 3) Severe diabetic peripheral neuropathy: > 39 mV

Statistical analysis and ethical considerations: Data was entered in MS Excel and analyzed using SPSS Version 22. Categorical variables were described using frequency and percentage and Continuous variables will be described using mean and standard deviation. Chi-Square test was used to test the association and p value <0.05 was considered as statistical significance. Informed consent and Institutional Ethical Committee (Ref No: VMKVMC&H/IEC/23/001) were obtained from all the study participants prior to conduction of the study.

RESULTS

Demographics and Socioeconomic factors: Among the study population, 78.6% were above 50 years of age and the mean age was 58.61±9.41 Years. More than half (54%) of the participants were female, and nearly 41.7% were illiterate. About 50% were involved in unskilled work and only 8.6% were skilled workers. As per Modified B G Prasad socioeconomic status classification, 47.7% belonged to lower class and 28.9% were in lower middle category. (Table 1)

Figure 1: Prevalence of Diabetic Peripheral Neuropathy as per MNSI History Version and MNSI Physical Examination Version (N – 350)

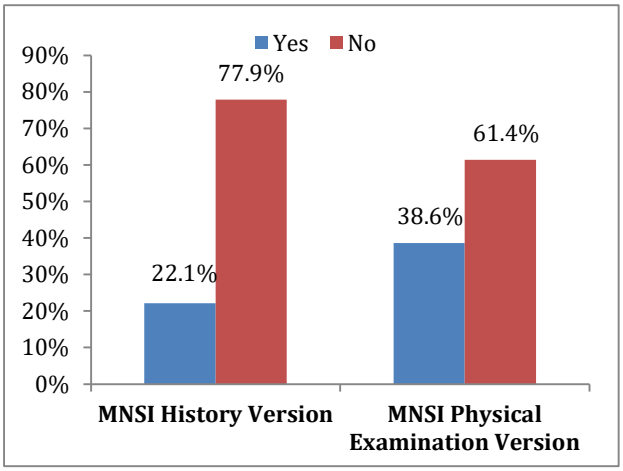

Table 1: Sociodemographic Characteristics of Study Participants (N= 350)

Variable	Participants (%)
Age	
≤50 Years	75 (21.4)
>50 Years	275 (78.6)
Sex	
Female	189 (54)
Male	161 (46)
Educational status	
Illiterate	146 (41.7)
Primary school	36 (10.3)
Middle school	106 (30.3)
High school	60 (17.1)
Post high school diploma	2 (0.6)
Occupation	
Unemployed	69 (19.7)
Unskilled worker	175 (50)
Semiskilled worker	50 (14.3)
Skilled worker	30 (8.6)
Farmer	26 (7.4)
Socioeconomic status[28*]	
Upper class	10 (2.9)
Upper middle	24 (6.9)
Lower middle	101 (28.9)
Upper lower	48 (13.7)
Lower	167 (47.7)
Family type	
Nuclear family	210 (60)
Joint family	84 (24)
Three generation family	56 (16)

*Socioeconomic status was calculated using Modified BG Prasad 2024 classification

Table 2: Findings of MNSI physical examination (N – 350)

Variable	Right foot (%)	Left foot (%)
Appearance of feet		
Normal	275 (78.6)	273 (78)
Abnormal	75 (21.4)	77 (22)
Ulceration		
Present	24 (6.8)	18 (5.1)
Absent	326 (93.2)	332 (94.9)
Ankle reflexes		
Present	293 (83.7)	291 (83.1)
Present / Reinforcement	17 (4.9)	23 (6.6)
Absent	40 (11.4)	36 (10.3)
Vibration perception at great toe		
Present	271 (77.4)	270 (77.1)
Decreased	41 (11.7)	41 (11.7)
Absent	38 (10.9)	39 (11.2)
Monofilament test		
Normal	283 (80.9)	277 (79.1)
Reduced	38 (10.9)	41 (11.7)
Absent	29 (8.2)	32 (9.1)

Diabetes history and treatment: In this study, duration of diabetes mellitus was > 10 years in 38.9% of them and 40.5% were suffering from diabetes mellitus for ≤ 5 years. Majority (90%), of the diabetic patients were treated with any of the oral hypoglycemic drugs only and about 84.6% were getting treatment from government sector.

Table 3: Univariate analysis between selected variables and Diabetic Peripheral Neuropathy (N – 350)

Variable	Cases	Diabetic Peripheral Neuropathy		P value	Odds Ratio (95% CI)
		Yes (n=135)	No (n=215)		
Age					
> 50 Years	275	121 (89.6%)	154 (71.6%)	**0.0007***	2.94 (1.57-5.53)
≤ 50 Years	75	14 (10.4%)	61 (28.4%)		Ref
Sex					
Male	161	83 (61.5%)	78 (36.3%)	**<0.0001***	2.90 (1.79-4.37)
Female	189	52 (38.5%)	137 (63.7%)		
Duration of Diabetes Mellitus					Ref
>5 Years	208	109 (80.7%)	99 (46%)	**<0.0001***	4.91 (2.96-8.13)
≤5 Years	142	26 (19.3%)	116 (54%)		Ref
Treatment compliance					
Good	254	96 (71.1%)	158 (73.5%)	0.627	0.88 (0.54-1.43)
Poor	96	39 (28.9%)	57 (26.5%)		Ref
Blood sugar levels					
Controlled	217	101 (74.8%)	116 (54%)	**<0.0001***	2.53 (1.58-4.06)
Uncontrolled	133	34 (25.2%)	99 (46%)		Ref
Diabetes mellitus in family members					
Yes	110	36 (26.7%)	74 (34.4%)	0.215	0.74 (0.46-1.18)
No	240	99 (73.3%)	151 (70.2%)		Ref
Smoking					
Yes	55	20 (14.8%)	35 (16.3%)	0.714	0.89 (0.49-1.62)
No	295	115 (85.2%)	180 (83.7%)		Ref
Alcohol use					
Yes	36	11 (8.1%)	25 (11.6%)	0.299	0.67 (0.32-1.41)
No	314	124 (91.9%)	190 (88.4%)		Ref
Physical inactivity					
Yes	167	89 (65.9%)	78 (36.3%)	**<0.0001***	3.39 (2.16-5.33)
No	183	46 (34.1%)	137 (63.7%)		Ref
Presence of hypertension					
Yes	221	113 (83.7%)	108 (50.2%)	**<0.0001***	5.08 (2.99-8.63)
No	129	22 (16.3%)	107 (49.8%)		Ref
Body Mass Index					
Underweight / Normal	274	102 (75.6%)	172 (80%)	0.326	0.77 (0.46-1.29)
Overweight / Obese	76	33 (24.4%)	43 (20%)		Ref

*P value < 0.05 is considered as statistically significant

Table 4: Multivariate binomial logistic regression analysis findings

Variable	Diabetic Peripheral Neuropathy		
	P value	Adjusted Odds Ratio (AOR)	95% CI
Age (> 50 years)	0.211	0.87	0.56 - 1.15
Male gender	**0.011**	1.33	1.07 – 1.48
Duration of diabetes mellitus (> 5 years)	**< 0.0001**	3.12	1.98 - 5.75
Uncontrolled blood sugar	**< 0.0001**	2.57	1.77 - 3.61
Physical inactivity	0.397	0.91	0.56 - 1.14
Presence of Hypertension	**0.004**	1.61	1.09 – 1.64

Enter method was used for multivariate analysis. Model was found to be statistically significant (Cox and Snell R2 – 0.361, Nagelkerke R2 –0.458).

Around 72.6% were having good compliance to treatment and only 62% of the diabetics had their blood sugar levels under control. Also 31.4% had a positive family history of diabetes mellitus.

Lifestyle and risk factors: Among the diabetics, 15.7% were smokers and 10.3% consume alcohol regularly. More than half 52.3% of the study participants were physically inactive and nearly 63.2% were hypertensive too. Based on WHO classification of BMI, 73.7% were in the normal category and 21.7% were either overweight or obese

Prevalence and symptoms of DPN: In our study, 22.1% of the diabetic individuals have Diabetic Peripheral Neuropathy as per the history version of MNSI questionnaire. Whereas, as per the physical examination version of MNSI about 38.6% were having Diabetic Peripheral Neuropathy (Figure 1)

With respect to symptoms of diabetic peripheral neuropathy, 56% had cracks in feet, 42% reported legs hurt while walking, 40% had burning pain in legs and /or feet, 38.6% reported that the symptoms worsen during night and 16.3% reported that doctor had informed them that they have neuropathy. All the study participants were able to differentiate between cold and hold water and none of them underwent amputation before.

In this study, on a average 21.7% had abnormally appearing feet, 5.9% had ulcers, ankle reflex was ab-

sent in 10.8%, about 11.5 had absent vibration perception at great toe and 8.6% had absent response on monofilament test (Table 5). Severity of DPN was graded using Biothesiometer among the diabetic patients and only 61.4% were normal. Also, 16.5%, 9.5% and 12.6% respectively had Mild DPN, Moderate DPN and Severe DPN

Statistical Associations with DPN: Variables significantly associated with DPN in univariate analysis (As per MNSI Physical examination) include age > 50 years (OR 2.94, P value - 0.0007), Male Gender (OR 2.90, P value -< 0.0001), duration of diabetes mellitus > 5 years (OR 4.91, P value -< 0.0001)., uncontrolled blood sugar levels, (OR 2.53, P value -< 0.0001), physical inactivity (OR 3.39, P value -< 0.0001) and presence of hypertension (OR 5.09, P value -< 0.0001).

Variables those were significant in univariate analysis were included for multivariate binomial logistic regression analysis using enter method (Table 4). Male gender (p value = 0.011, AOR – 1.33), Duration of diabetes mellitus (p value = <0.0001, AOR – 3.12), uncontrolled blood sugar levels (p value = < 0.0001, AOR – 2.57) and presence of hypertension (p value = 0.004, AOR – 1.61) were significantly associated with Diabetic Peripheral Neuropathy based on multivariate analysis (Table 4).

Discussion

In our study, mean age was 58.61±9.41 Years and more than half 54% were females. About 50% were unskilled worker and only 8.6% were skilled workers. Also, 47.7% belonged to lower class and 28.9% were in lower middle category. A higher proportion of males was reported in studies by Kamalarathnam SR and Darivemula S et al.[1,16] Our findings align with Vibha SP et al study, mean age was 63.37±10.8 years was, 57.4% were females and 11.7% were skilled workers.[17] Similar trends to our study of mean age and female preponderance were seen in studies by Baxi H et al, Rakesh PS et al and Bashar A et al.[13,18,19] About, 52.4% were females and 57.6±12.2 Years was the mean age in study by D'Souza M et al.[14]

In our study, 38.9% of participants had diabetes for more than 10 years. Among them, 90% were on oral hypoglycemic drugs, yet only 62% achieved blood sugar control. Kamalarathnam SR et al noted that mean diabetic duration was 6.2±5.3 Years and 52% had uncontrolled fasting and postprandial blood sugar levels in their study.[1] Median duration of diabetes was 7±3.13 Years. 89.6% were on oral hypoglycemic agents, 96.1% were complaint to treatment and study 53.2% gave a positive family history in study by Vibha SP et al.[17] In concordance to our study, D'Souza M et reported that 48.7% had uncontrolled fasting blood sugar levels.[14]

With respect to lifestyle risk factors, 15.7% were smokers, 10.3% consume alcohol, 52.3% were physically inactive, 63.2% were hypertensive and 21.7% were either overweight or obese, Whereas, lifestyle risk actor prevalence was higher in Bashar A et al study 36% were smokers, 28% consume alcohol, 73% were physically inactive, 76% were either overweight or obese and 76% had uncontrolled blood pressure.[19] Vibha et al study recorded that 18.1% consume alcohol, 6.5% smoke and 51% were physically inactive.[17] About 87.7% were physically active, 47.6% were overweight and 19.1% were obese, 17.6% consume alcohol and 16.7% were either ever smoker or current smoker.in Kamalarathnam SR et al study.[1] Nearly 18.3% were smokers and 14.9% were alcoholics in D'Souza M et al study.[14] This difference in the lifestyle risk factor prevalence might be due to demographic differences, sociocultural influences, educational background and study setting.

In this study, 56% had cracks in feet, 42% reported legs hurt while walking, 40% had burning pain in legs and/or feet, 38.6% reported that the symptoms worsen during night and 30.3% experienced muscle cramps. Kamalarathnam SR et al study symptoms of DPN reported include legs hurting while walking (46.6%) followed by burning sensation in the feet (37.7%).[1] As per MNSI, 72.6% were Feeling of weakness all over most of the time, 65.4% reported Legs hurt while walking 63% experienced Prickling feelings in legs or feet and 62.5% reported Muscle cramps in legs and/or feet in D'Souza M et al study.[14] About more than one-third had callosity over foot, 36.9% had numbness of the foot, 50% of them had pricking sensation in the foot and 61% had a burning foot sensation in study by Darivemula S et al.[16]

Around 22.1% and 38.6% of the diabetic individuals have Diabetic Peripheral Neuropathy as per MNSI questionnaire history version and physical examination version respectively in our study. Similar DPN prevalence was noted in studies by Kamalarathnam SR et al[1], Baxi H et al[13], D'Souza M et al[14], Bansal D et al[15], Darivemula S et al[16], Bashar A et al[19], Pawde PP et al[20] and Jasmine A et al[21]. Whereas on the contrary DPN prevalence was 51.8%, 74%, 51.8%, 50.7%, 56% and 67% respectively in the studies by Vidha SP et al[17], Wickramasinghe T P et al[22], Shamim A et al[23], Bondar AC et al[24], Al Washali A.Y et al[25], Kärvestedt L et al[26]. The differences in DPN prevalence across studies may be attributed to variations in demographic profiles, diagnostic criteria, diabetes duration, and study settings. Notably, studies from developed countries reported higher DPN prevalence, possibly due to better diagnostic tools or longer life expectancy among diabetic patients.

In our study 16.5%, 9.5% and 12.6% respectively had Mild DPN, Moderate DPN and Severe DPN based on Biothesiometer readings. Whereas in Bansal D et al[15] study prevalence of mild, moderate, and severe neuropathies was 8.06, 14.55 and 6.63%, respectively. Vaibha et al[17] study recorded that 31.3, 11.9 and 8.5% belonged to category 1, 2 and 3 of diabetic foot syndrome category respectively. Prevalence of mild,

moderate and severe DPN was respectively 5.9%, 7.9% and 5% in study by Rani P et al[27].

Male gender, Duration of diabetes mellitus, uncontrolled blood sugar levels and presence of hypertension were significantly associated with Diabetic Peripheral Neuropathy based on multivariate analysis in our study. Similar results were noted in studies by Kamalarathnam SR et al[1], Baxi H et al[13], D'Souza M et al[14], Bansal D et al[15], Darivemula S et al[16], Bashar A et al[19], Pawde PP et al[20] and Jasmine A et al[21], Vidha SP et al[17], Wickramasinghe T P et al[22], Shamim A et al[23], Bondar AC et al[24], Al Washali AY et al[25], Kärvestedt L et al[26]. Whereas variable like smoking, alcohol use and socioeconomic status were not significant in our study which was in contradiction to other studies.[14,15,17,19,23]

Conclusion

Around 22.1% and 38.6% of the diabetic individuals have Diabetic Peripheral Neuropathy as per MNSI questionnaire history version and physical examination version and also, 16.5%, 9.5% and 12.6% respectively had Mild DPN, Moderate DPN and Severe DPN based on Biothesiometer. A significant proportion of individuals with DPN were asymptomatic, emphasizing the importance of early screening to prevent complications.

Mandatory DPN screening should be integrated into diabetes care protocols at all levels of the health system to facilitate early detection and management. Adequate training of the field staff regarding screening tools at the primary care level will tremendously help reducing the impact of DPN through early detection and management. General public and diabetic individuals should be effectively educated about the complications of diabetes mellitus and measures to prevent them. Healthcare providers should educate diabetic individuals on the importance of routine foot care and self-care practices to prevent complications.

Data availability statement: For any queries, kindly mail your requests to vijay.doc09@gmail.com.

No generative AI tools: This article was prepared without the use of generative AI tools for content creation, analysis, or data generation. All findings and interpretations are based solely on the authors' independent work and expertise.

Author contribution: SPN: Contributed to study conception, design, and data collection. Participated in manuscript preparation. **VM:** Contributed to study conception, data collection, manuscript preparation, data analysis and interpretation. **MDT:** Involved in study conception, data analysis, and manuscript preparation.

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