

Original Article

Diabetic peripheral neuropathy and its determinants among patients attending a tertiary health care centre in Mangalore, India

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Significance for public health

The findings of the current research hold importance since diabetes is one of the leading causes of morbidity and mortality across the world. Due to its chronic nature and effects of hyperglycaemia, diabetes tends to be associated with many comorbidities, like peripheral neuropathy, nephropathy, retinopathy etc. The presence of diabetic peripheral neuropathy leads to a reduced quality of life among diabetic patients due to the trauma and consequent gangrenes and amputation. The concept of secondary prevention can be applied to the prevention of diabetic peripheral neuropathy using easy to apply screening tools and thus help in early diagnosis and treatment to reduce the burden of this debilitating illness.

Abstract

Background. The burden of diabetes mellitus (DM) is on the rise especially in developing countries like India. Due to its chronic nature DM tends to cause many debilitating complications and diabetic peripheral neuropathy (DPN) is one of them. The aim of this study is to determine the prevalence of DPN among patients attending a tertiary care hospital and to identify the determinants associated with it.

Design and methods. A cross sectional study was conducted in Government Wenlock Hospital, Mangalore (India), during January-February 2014. A total of 208 patients with >5 year duration of DM were asked to respond to the patient history version of Michigan Neuropathy Screening Instrument (MNSI) and examinations were conducted after obtaining consent from them. The statistical analysis was done in terms of descriptive statistics and association between variables was tested using logistic regression test.

Results. The prevalence of DPN using the MNSI history version and MNSI examination were found to be 18.3% and 32.2% respectively. The major determinants associated with DPN were found to be male gender (OR: 2.7, CI: 1.4-5.1, P=0.001), smoking (OR: 5.8, CI: 1.9-17.3, P=0.001) and age >40 years (OR: 2.7, CI: 1.2-5.8, P=0.011).

Conclusions. The burden of undetected DPN was found to be higher among diabetics, with an especially higher prevalence among males, smokers and those with long standing diabetes mellitus. Interventions in the form of early detection through routine screening, smoking cessation and regular follow up examinations would go a long way in reducing the burden of disability among diabetics and improve their quality of life significantly.

Background

Diabetes mellitus (DM) is a major public health problem worldwide. According to the International Diabetes federation, 387 million people

have diabetes in the year 2014 and by the year 2035 the numbers will rise to 592 million. The greatest number of cases of diabetes mellitus is recorded in the age group between 40 and 59 years of age. With a national DM prevalence of 8.6% and 668,468,800 number of people with DM, India stands second to China in relation to the burden of DM.¹

Diabetes mellitus is a group of metabolic disorders which has a common underlying feature of hyperglycaemia. Diabetes mellitus is characterised by a long standing state of hyperglycaemia in a person. It is a well-known fact that the average time gap between the onset of diabetes and its detection in an individual is 4 to 7 years.² As a result of prolonged hyperglycaemic state along with degenerative changes secondary to ageing, there are injurious effects to the tissues leading to micro vascular and macro vascular complications. The macro-vascular complications include coronary artery disease, peripheral arterial disease and stroke. The micro vascular complications include retinopathy, diabetic nephropathy and peripheral neuropathy.³

One of the most chronic and debilitating complication of diabetes is diabetic peripheral neuropathy (DPN). Diabetic neuropathies are a group of nerve disorders caused by persistent high blood sugar levels. As a consequence of damage to the nerves the patients develop the inability to perceive important sensations like heat, cold and pain in extremities. As a result of lack of these sensations the patient may not be aware of a sore or an ulcer in the foot. This coupled with delayed/non healing of ulcers due to DM, most of the patients end up losing their limbs. The major problem with the development of DPN is that the changes are subtle and happen as people get older, people tend to ignore the signs of nerve damage, thinking it's just part of getting older.⁴ Available evidence suggests that the presence of DPN among patients with diabetes leads to reduced quality of life, mainly attributable to the morbidity and mortality associated with DPN.⁵⁻⁷ Hence, the problem of DPN demands the application of concept of secondary prevention through early diagnosis and treatment. Screening for DPN in clinical practice using a simple objective tool is essential, as the detection of the various soft and subtle signs of DPN at the earliest could minimize the damaging effects of this serious but manageable micro vascular complication and in turn improve the quality of life of such patients.

This study was conducted with the objective to screen type 2 diabetic patients for undetected DPN and also to identify the determinants of diabetic peripheral neuropathy among type 2 diabetic patients.

Design and Methods

Study design

Facility based cross sectional study

Study setting

The present study was conducted among patients with type-2 DM

attending out-patient departments (OPDs) of Government Wenlock Hospital (GWH), an associate hospital of Kasturba Medical College (KMC) Mangalore, Karnataka. The city of Mangalore is located in the coastal region of Karnataka state, India. It is the second fastest developing city of Karnataka state, with a highly industrialized work environment. The prevalence of DM in the coastal Karnataka is 16%.⁸ The GWH is a tertiary care level district hospital, which is having a public private partnership (PPP) with KMC, Mangalore. The GWH caters to the residents of Mangalore city and the surrounding suburbs. The OPD case load for every day ranges from 200 to 300 patients, among whom 60-70 patients will be with diabetes for follow up care. Apart from everyday medical OPDs, on every Wednesday diabetes clinic is conducted. The patients with diabetes are, usually, attended by the consultant doctors, junior residents and interns.

Study duration

The study was conducted over two month's duration from 1st January 2014 to 28th February 2014.

Study participants

The study included patients with type 2 DM with duration since diagnosis of more than five years. A sample size of 243 was calculated considering a power of 80%, an absolute precision of 5%, and a confidence level of 95% and a DPN prevalence rate of 19.1% among Indian diabetic patients.⁹ The study participants were selected using convenient sampling.

Study tool

The screening for DPN was conducted using the Michigan Neuropathy Screening Instrument (MNSI). The MNSI is a validated tool for the screening of DPN in both community and hospital set ups.¹⁰ The MNSI includes two parts, the first part is related to patient's perception of symptoms in relation to DPN and the second part consists of a set of examinations done to detect the presence of DPN among the patients. The examinations include, i) vibration sensation test using a 128 Hz tuning fork, ii) elicitation of muscle jerk reflex at the ankle joint and iii) monofilament testing. The investigators were trained with regards to proper conduct of examinations using the MNSI tool. All the examinations conducted by the investigators were supervised by the post graduates of Department of Internal Medicine, KMC, Mangalore. The screening activities were conducted after obtaining a written informed consent from the participants in a separate examination room.

Scoring of Michigan Neuropathy Screening Instrument history version

The first part of the MNSI questionnaire asks the participants about the presence or absence of symptoms related to DPN. Responses are added to obtain the total score. Responses of *yes* to items 1-3, 5-6, 8-9, 11-12, 14-15 are each counted as one point. A *no* response on items 7 and 13 counts as 1 point. Item number 4 is a measure of impaired circulation and item number 10 is a measure of general asthenia and is not included in scoring. A score of ≥ 7 was taken as positive for the DPN.

Scoring of Michigan Neuropathy Screening Instrument examination version

After examining the patient's both extremities, each component is given a score of 0 if no finding is present and a score of 1 if any abnormality was detected. After summing up all the components if the overall score was found to be ≥ 2.5 , then it was considered to be positive for the presence of DPN.

Apart from MNSI, we also collected information in relation to socio-demographic aspects such as age, gender, marital status, literacy, smoking and alcohol consumption. The information in relation to the control of blood sugar level was collected based on the last fasting blood

sugar (FBS) levels examination conducted in last 30 days, the records of which were written on patient's out-patient cards. Since, it is the policy of the hospital to test for FBS once in 3 months; the information was available for only 78 subjects.

Data analysis

The collected information was entered and analysed using SPSS version 16. The data was analysed in terms of descriptive statistics as well as bivariate analysis (Chi-square test). We undertook both unadjusted and adjusted logistic regression to assess the association between socio-demographic variables (age, sex, marital status, literacy, smoking, alcoholic status), clinical variables (duration of illness) and prevalence of DPN. The variables which were found to be significant on bivariate analysis (*viz.* gender, smoking status, alcohol consumption and age groups) were subjected for logistic regression. The fit of the logistic model was assessed with the Hosmer and Lemeshow goodness-of-fit test; $P < 0.05$ was considered evidence of a statistically significant difference between predictive and outcome variables. Odds ratios (ORs) and corresponding 95% confidence intervals (CIs) are reported.

Ethical considerations

Prior to the start of the study approval was obtained from the Institutional Ethics Committee of KMC, Mangalore. A written informed consent was obtained from all the study participants. All the collected information has been kept confidential.

Results

Among the 243 participants who were found to be eligible and approached by the investigators, 208 patients with diabetes consented to participate in our study. The response rate comes out to be 85.6%. Among them 99 (47.6%) were males and 109 (52.4%) were females. The mean age of the study participants was found to be 57.6 ± 12.2 years (range 33-82 years). The mean duration of diabetes mellitus in the study population was found to be 9.8 ± 2.8 years (range 5-40 years). The remaining socio-demographic details of the participants have been provided in Table 1.

Results based on Michigan Neuropathy Screening Instrument history (patient version)

Based on the scoring of MNSI patient version, the prevalence of DPN was found out to be 18.3% ($n=38$). Table 2 presents the details of the MNSI history version.

The prevalence of DPN was significantly higher among males, smokers and alcoholics. The prevalence of DPN was also found to be higher among patients who were more than 40 years old, with a fasting blood glucose (FBG) of more than 120 g/dL, unmarried/widowed/divorced individuals and those with duration of DM >10 years; however the association was not statistically significant (Table 3).

On binary logistic regression, smoking, alcoholism and male gender were found to be significant risk factors for DPN. The corresponding Odds ratios and confidence intervals have been mentioned in detail in Table 4.

However, on multivariate logistic regression the risk factors which were found to be associated with DPN were: male gender [OR: 2.4 (1.0-5.6), $P=0.046$] and smoking [OR: 10.2 (3.1-33.9), $P=0.001$] (Table 4).

Results based on Michigan Neuropathy Screening Instrument examination (signs)

The prevalence of Diabetic Peripheral Neuropathy was found to be 32.2% ($n=67$) among the study participants. The prevalence of DPN

Table 1. Profile of study participants (N=208).

| Parameter | N. | % |
|---|-----|------|
| Age (in years) | | |
| 31-40 | 21 | 10.1 |
| 41-50 | 50 | 24.0 |
| 51-60 | 48 | 23.1 |
| 61-70 | 48 | 23.1 |
| 71-80 | 36 | 17.3 |
| 81-90 | 5 | 2.40 |
| Education | | |
| Literates | 186 | 89.4 |
| Illiterates | 022 | 10.6 |
| Marital status | | |
| Married | 187 | 89.9 |
| Unmarried | 021 | 10.1 |
| Smoking history | | |
| Smokers | 038 | 18.3 |
| Non-smokers | 170 | 81.7 |
| Alcohol consumption | | |
| Alcoholics | 031 | 14.9 |
| Non-alcoholics | 177 | 85.1 |
| Duration since diagnosis of diabetes mellitus | | |
| Less than 10 years | 144 | 69.2 |
| More than 10 years | 064 | 30.8 |
| Fasting blood glucose levels* | | |
| More than 120 mg/dL | 038 | 48.7 |
| Less than 120 mg/dL | 040 | 51.3 |

*This information is available for only 78 subjects.

Table 2. Summary of participants responses to Michigan Neuropathy Screening Instrument history questionnaire (n=208).

| Symptom | N. | % |
|---|-----|------|
| Numbness of legs and/or feet | 95 | 45.7 |
| Burning pain in legs and/or feet | 104 | 50.0 |
| Feet too sensitive to touch | 55 | 26.4 |
| Muscle cramps in legs and/or feet | 130 | 62.5 |
| Prickling feelings in legs or feet? | 131 | 63.0 |
| Feeling of hurt when the bed covers touch skin | 25 | 12.0 |
| Ability to tell the hot water from the cold water? | 13 | 6.3 |
| Ever had an open sore on the foot | 76 | 36.5 |
| Doctor ever told you that you have diabetic neuropathy? | 29 | 13.9 |
| Feeling of weakness all over most of the time | 151 | 72.6 |
| Symptoms worse at night | 113 | 54.3 |
| Legs hurt while walking | 136 | 65.4 |
| Ability to sense your feet while walking | 37 | 17.8 |
| Is the skin on your feet so dry that it cracks open? | 50 | 24.0 |
| Ever had an amputation | 0 | 0 |
| Participants with a score of ≥ 7 | 38 | 18.3 |

Table 4. Unadjusted and adjusted odds ratios (ORs) for determinants associated with diabetic peripheral neuropathy according to Michigan Neuropathy Screening Instrument history version.

| Determinant | Unadjusted ORs | | Adjusted ORs | |
|---------------------------------|----------------|---------|-----------------|---------|
| | OR (CI) | P-value | OR (CI) | P-value |
| Male sex | 2.7 (1.4-5.1) | 0.001 | 2.3 (1.0-5.6) | 0.046 |
| Smokers | 4.5 (2.6-7.6) | <0.0001 | 10.2 (3.0-33.9) | 0.001 |
| Alcoholics | 2.3 (1.3-4.2) | 0.007 | 2.6 (0.7-9.7) | 0.155 |
| Age >40 years | 1.7 (0.9-3.0) | 0.060 | 1.8 (0.8-4.1) | 0.136 |
| Fasting blood glucose >120 g/dL | 2.7 (0.9-7.8) | 0.059 | 3.0 (0.7-12.2) | 0.111 |

was significantly higher among males, smokers, and alcoholics, patients who were more than 40 years old (Figure 1) and with a Fasting Blood Glucose (FBG) of more than 120 g/dL. The prevalence of DPN was also found to be higher among unmarried/widowed/divorced individuals and those with duration of DM >10 years; however the association was not statistically significant (Table 5).

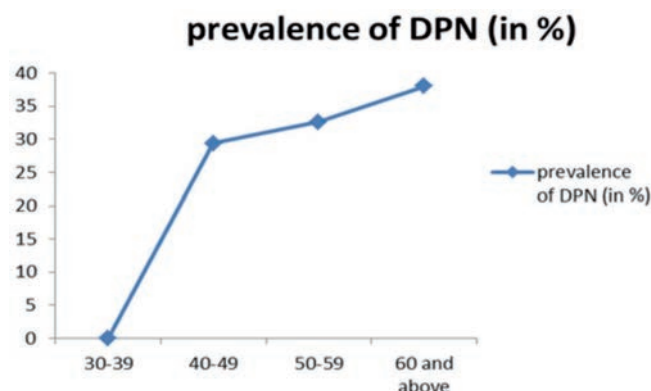


Figure 1. Age group wise trends of diabetic peripheral neuropathy among study population.

Table 3. Socio-demographic factors of the study participants associated with diabetic peripheral neuropathy according to the Michigan Neuropathy Screening Instrument history version-bivariate analysis (n=38).

| | N. | % | P-value |
|----------------------------|----|------|---------|
| Gender | | | 0.001 |
| Males | 27 | 27.3 | |
| Females | 11 | 10.1 | |
| Cigarette smoking | | | <0.0001 |
| Smokers | 19 | 50.0 | |
| Non-smokers | 19 | 11.2 | |
| Alcoholic status | | | 0.007 |
| Alcoholics | 11 | 35.5 | |
| Non-alcoholics | 27 | 15.3 | |
| Age | | | 0.043 |
| 30-39 years | 3 | 21.4 | |
| 40-49 years | 13 | 25.5 | |
| 50-59 years | 7 | 16.3 | |
| 60 years and older | 15 | 15.0 | |
| Fasting blood glucose | | | 0.054 |
| More than 120 mg/dL | 7 | 17.5 | |
| Less than 120 mg/dL | 14 | 36.8 | |
| Marital status | | | 0.198 |
| Married | 32 | 17.1 | |
| Unmarried/divorced/widowed | 6 | 28.6 | |

On binary logistic regression, smoking, alcoholism and male gender were found to be significant risk factors for DPN. The corresponding Odds ratios and confidence intervals have been mentioned in detail in Table 6.

To eliminate the effects of confounding bias, we undertook multivariate logistic regression. Based on this analysis, the risk factors which were found to be associated with DPN were: smoking (OR: 5.9, CI: 1.9-17.3, P=0.0001) and age more than 40 years (OR: 2.7, CI: 1.2-5.8, P=0.011) (Table 6).

Discussion

The present study was conducted to assess the prevalence of DPN among patients attending a tertiary care hospital. Majority of the participants in our study (65.9%) belonged to the age group of more than 60 years. As per the existing national statistics, individuals aged above 60 years constitute 7.5% of the total population.¹¹ A proportionately higher number of older patients in our study can be explained by the

Table 5. Socio-demographic factors of the study participants associated with diabetic peripheral neuropathy according to the Michigan Neuropathy Screening Instrument examination version-bivariate analysis (n=67).

| | N. | % | P-value |
|-------------------------------|----|------|---------|
| Gender | | | 0.003 |
| Males | 42 | 42.4 | |
| Females | 25 | 22.9 | |
| Cigarette smoking | | | <0.0001 |
| Smokers | 26 | 68.4 | |
| Non-smokers | 41 | 24.1 | |
| Alcoholic status | | | 0.039 |
| Alcoholics | 20 | 64.5 | |
| Non-alcoholics | 47 | 26.6 | |
| Age | | | 0.039 |
| 30-39 years | 0 | 0 | |
| 40-49 years | 15 | 29.4 | |
| 50-59 years | 14 | 32.6 | |
| 60 years and older | 38 | 38.0 | |
| Fasting blood glucose | | | 0.001 |
| More than 120 mg/dL | 21 | 55.3 | |
| Less than 120 mg/dL | 7 | 17.5 | |
| Marital status | | | 0.543 |
| Married | 59 | 31.6 | |
| Unmarried/divorced/widowed | 8 | 38.1 | |
| Duration of diabetes mellitus | | | 0.277 |
| More than 10 years | 43 | 29.9 | |
| Less than 10 years | 24 | 37.5 | |

fact that NCDs commonly occur in old age and usually the diagnosis is delayed due to late manifestations and detection of the disease.

The prevalence of DPN according to the patient history version was found out to be 18.3%. The prevalence was much lesser compared to the one that we found on the basis of MNSI examination which was 32.2%. Similar findings were observed in a study conducted in UAE.¹² The difference in prevalence rates using two methods is an important finding and it clearly demonstrates the limitations related to patient's self-perception of symptoms of DPN. Furthermore, it highlights the importance of screening for DPN among the people with diabetes for early detection and treatment using screening techniques that involve examination of the patient.

The prevalence of DPN using MNSI examination in our study was found to be 32.2%. Our findings are similar to studies conducted in Iran, Turkey and Spain.¹³⁻¹⁶ However, the prevalence of DPN in other studies conducted elsewhere showed a lot of variation, ranging from 13% to 75%.^{8,17-24} The difference in prevalence of DPN across the studies can be attributed to differences in diabetes duration, study designs, type of study population included and different types of scales used to assess the magnitude of DPN in different study settings. Nonetheless, the high prevalence of DPN in our study highlights the importance of proper foot care and adequate blood sugar control among diabetics.

After conducting multivariate logistic regression, we observed that smoking (OR-5.9, CI: 1.9-17.3) was found to be significantly associated with DPN. Similar findings were observed in studies conducted elsewhere.^{21,23} However no such association was observed in a study conducted in Iran.²⁴ The association between smoking and DPN can be explained with the fact that smoking itself is an independent risk factor for peripheral neuropathy; with the addition of DM the combination appears to be synergistic. Also, age >40 years was found to be a significant risk factor (OR-2.7, CI: 1.2-5.8) associated with DPN. Similar findings were observed in other studies.^{9,14-16,25,26} Ageing is a well-known risk factor for many non-communicable diseases including DM. The effects of ageing combined with deleterious effects of hyperglycaemia can result in increased prevalence of DPN as one gets old.

Upon multivariate analysis of the MNSI history version, we also observed that male gender was significantly associated with the development of DPN (OR-2.3 CI:1.0-5.6). Similar results were obtained in various other studies as well.^{24,27,28} However, studies conducted elsewhere did not observe a similar association.^{16,19,20,26}

The limitations of our study include the following: since, this is a facility based study which covers only that part of the diabetic population who approached for the assistance of clinicians in hospitals for follow up and management of their condition. Hence the conclusions deduced from this study cannot be generalized to the general population. The lack of nerve conduction velocity (NCV) studies which is the definite tool for diagnosing neuropathy, as well as aetiology determination of DPN (e.g., vitamin B12 or folic acid deficiency) further confines the effectiveness of the present study's outcome. Also, the study didn't account for other potential confounders such as musculo-skeletal conditions of the old age, nutritional deficiencies etc. which might mimic

Table 6. Unadjusted and adjusted odds ratios (ORs) for determinants associated with Diabetic Peripheral Neuropathy according to Michigan Neuropathy Screening Instrument examination version.

| Determinant | Unadjusted ORs | | Adjusted ORs | |
|---------------------------------|----------------|---------|----------------|---------|
| | OR (CI) | P-value | OR (CI) | P-value |
| Male sex | 2.5 (1.4-4.5) | 0.003 | 1.5 (0.7-2.9) | 0.215 |
| Smokers | 6.8 (3.1-14.7) | <0.0001 | 5.9 (1.9-17.3) | 0.001 |
| Alcoholics | 5.0 (2.2-11.3) | <0.0001 | 1.5 (0.5-4.8) | 0.440 |
| Age >40 years | 1.4 (1.0-2.0) | 0.017 | 2.7 (1.2-5.8) | 0.011 |
| Fasting blood glucose >120 g/dL | 5.8 (2.0-16.4) | 0.001 | 5.6 (0.6-9.9) | 0.430 |

the symptoms of DPN. Nonetheless, the present study has some strength in terms of use of a valid and easy to use scale on an adequate sample of population with reasonably good response rate among them.

Conclusions

Peripheral neuropathy is a permanent, irreversible, debilitating but preventable micro-vascular complication of uncontrolled diabetes mellitus, which if sets in a patient will have a significant devastating effect on his/her quality of life. From the results of this study we would like to conclude that the burden of DPN is high among diabetics, with an especially higher prevalence among males, smokers and people with long standing diabetes mellitus. Interventions in the form of early detection through routine screening and regular follow up examinations would go a long way in reducing the burden of disability among diabetics and improve their quality of life significantly.

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