Journal of Chemical Health Risks

www.jchr.org

JCHR (2025) 15(4), 2369-2375 | ISSN:2251-6727

Correlation between Serum Phosphate, Serum Magnesium levels and Severity of Peripheral Neuropathy in Patients with Type II Diabetes Mellitus

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(Received: 19 June 2025 Revised: 22 July 2025 Accepted: 12 August 2025)

KEYWORDS

Diabetic Peripheral Neuropathy, Type 2 Diabetes Mellitus, Serum Magnesium, Serum Phosphate, Toronto Clinical Neuropathy Score

ABSTRACT:

Background: Diabetic Peripheral Neuropathy (DPN) is one of the most prevalent microvascular complications of type II diabetes mellitus (T2DM). While magnesium and phosphate are essential for neuromuscular function, their association with DPN remains underexplored.

Objective: To assess the correlation between serum magnesium and phosphate levels with the severity of DPN in patients with T2DM.

Methods: This prospective observational study included 80 T2DM patients presenting with neuropathic symptoms. Severity of DPN was assessed using the Toronto Clinical Neuropathy Score (TCNS) and confirmed by nerve conduction studies. Serum magnesium and phosphate levels were measured and analysed against neuropathy severity.

Results: The mean age of participants was 51.77 ± 11.1 years. DPN prevalence was 75%, with significant associations found between neuropathy severity and reduced serum magnesium ($p=0.001$), phosphate levels ($p=0.003$), higher HbA1c ($p<0.001$), older age ($p<0.001$), male gender ($p=0.003$), and longer diabetes duration ($p=0.001$). Magnesium demonstrated a stronger predictive value for DPN severity than phosphate.

Conclusion: Serum magnesium and phosphate levels inversely correlate with DPN severity in T2DM. Serum magnesium may serve as a better predictive marker. Routine screening of these electrolytes could aid in early detection and management of DPN.

Introduction

Type 2 diabetes mellitus is a chronic metabolic disorder characterized by insulin resistance and relative insulin deficiency, leading to elevated blood glucose levels (hyperglycaemia). It is the most common form of diabetes, accounting for over 90% of all diabetes cases worldwide.[1] In type 2 diabetes, the body's cells become less responsive to insulin, and the pancreas is unable to produce enough insulin to maintain normal glucose levels. Risk factors include obesity, physical inactivity, unhealthy diet, family history of diabetes, age, and certain ethnic backgrounds.[2] Type 2 diabetes is a major cause of peripheral neuropathy. According to the American Diabetes Association, nearly 50% of people with diabetes experience some form of neuropathy

Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(4), 2369-2375 | ISSN:2251-6727

(ADA, 2023). Poor glycaemic control, duration of diabetes, and lifestyle factors contribute significantly to the development of peripheral nerve damage.[3] Magnesium, is one of the commonest intracellular cation, and is associated with transport of glucose intracellularly. Magnesium is an important enzyme activator at neuro-muscular junction and enhances permeability of cell. It is a vital element involved in cellular proliferation, nerve growth and apoptosis and crucial in immune pathways. Hypomagnesaemia in diabetic individuals is known to facilitate hyper stimulation of NMDA receptors, thereby lowering the pain threshold accounting to Diabetic peripheral neuropathy (DPN).[4] Low levels of phosphate will cause reduction in degradation of ATP into purine end products that shows a relation between phosphate and sustaining high energy charge inside the mitochondria. decreased ATP levels in neurons directly disturb function of nerves. Moreover, decreased phosphate levels may also cause reduced oxygen levels in nerves which is a result of increasing red blood cells oxygen affinity that subsequently cause injury to the nerve.[5] Against this background, the objective of the present study was to determine the correlation between serum phosphate, serum magnesium levels and severity of peripheral neuropathy with type 2 diabetes mellitus.

Materials and Methods

This prospective observational study was conducted at Chettinad Hospital and Research Institute over an 18-month period. The investigation enrolled 80 participants – patients and accompanying attendants – who had confirmed diabetic neuropathy; individuals with neuropathy attributable to other aetiologies were excluded. A comprehensive medical history was obtained for each participant, followed by a meticulous examination of the central nervous system. Patients with type 2 diabetes mellitus who exhibited neuropathic symptoms and signs subsequently underwent nerve conduction studies. Peripheral neuropathy severity was quantified using the Toronto Clinical Neuropathy Score (TCNS). In addition to routine laboratory tests, serum magnesium and serum phosphate concentrations were measured, and their correlation with neuropathy severity was analysed.

The TCNS integrates symptom scoring, reflex testing, and sensory examinations – including pinprick, temperature, light touch, vibration, and position sense – producing a total score between 0 and 19; higher scores denote more severe neuropathy. Its reproducibility and ease of application make it valuable for detecting both the presence and progression of diabetic peripheral neuropathy in clinical and research settings. Normative serum magnesium values range from 1.5 to 2.3 mg/dL, with concentrations below 1.5 mg/dL indicating hypomagnesaemia and those above 2.3 mg/dL indicating hypermagnesemia. Serum phosphate levels of 2.5 to 4.3 mg/dL are considered normal; values below 2.5 mg/dL define hypophosphatemia, whereas levels exceeding 4.3 mg/dL define hyperphosphatemia. Neuropathy severity was therefore assessed with the TCNS, electrophysiological confirmation was obtained through nerve conduction studies, and biochemical evaluation focused on serum magnesium and phosphate levels.

Results

A total of 80 patients with type 2 diabetes mellitus and symptoms suggestive of peripheral neuropathy were included. The demographic and clinical variables were analysed to determine the correlation between serum magnesium and phosphate levels with the severity of DPN. The mean age of the study population was 51.77 ± 11.1 years, indicating that most participants were middle-aged adults. The largest age group was between 41–50 years (35%), followed by 51–60 years (25%), reflecting a typical demographic profile for type 2 diabetes onset and complications. Males (62.5%) outnumbered females (37.5%), suggesting either a higher prevalence of diabetic neuropathy in males or a sampling trend. The duration of diabetes was more than 5 years in 61.25% of patients, with 38.75% having diabetes for 5–10 years, supporting the well-known fact that longer disease duration increases the risk for neuropathy. A high HbA1c (>9%) was observed in 57.5% of participants, indicating poor glycaemic control in a majority of the study population. This aligns with increased risk and severity of diabetic complications, particularly neuropathy (Table 1).

The overall incidence of DPN among our study subjects (n=80) was found to be 75.00% (n=60) and the incidence of patients without neuropathy among our study subjects was found to be 25.00% (n=20). The DPN group subjects were distributed as mild DPN (n=18), moderate DPN(n=25) and severe DPN(n=17) (Figure 1).

Journal of Chemical Health Risks

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JCHR (2025) 15(4), 2369-2375 | ISSN:2251-6727

The mean age increases steadily from 46.6 years (No Neuropathy) to 60.35 years (Severe DPN). There is a significant correlation ($p = 0.001$) between increasing age and DPN severity. Ageing appears to be an important risk factor for the development and progression of neuropathy. Male representation rises from 35% in the No Neuropathy group to 76.5% in the Severe DPN group. Male gender is significantly associated ($p = 0.003$) with more severe forms of DPN. This could reflect physiological, behavioural, or care-seeking differences between gender. There is a strong correlation ($p < 0.001$) between poor glycaemic control and increasing neuropathy severity. This reinforces the importance of tight blood sugar control in preventing or delaying neuropathic complications. Levels decline from 2.13 mg/dL in No Neuropathy to 1.38 mg/dL in Severe DPN. This shows a significant inverse relationship ($p = 0.001$) between magnesium levels and DPN severity. Hypomagnesemia may contribute to nerve dysfunction and worsen neuropathy in diabetic patients. Levels fall from 3.91 mg/dL to 3.13 mg/dL across the severity spectrum. Serum phosphate also shows a statistically significant inverse correlation ($p = 0.003$) with neuropathy severity, suggesting it too plays a role though the association is slightly weaker than that of magnesium (Table 2).

In all diabetic peripheral neuropathy patients <1.25mg/dl was taken as cut off value for serum magnesium for developing severe or moderate diabetic neuropathy with a sensitivity of 85% and a specificity of 82%. And <1.95mg/dl was taken as cut off value for serum phosphorous for developing severe or moderate diabetic neuropathy with a sensitivity of 79% and a specificity of 75% (Figure 2).

Serum magnesium exhibited the most pronounced inverse association with neuropathy severity, indicating that declining magnesium concentrations – and consequent hypomagnesaemia – may serve as an early biochemical warning for DPN. Serum phosphate levels also fell as neuropathy worsened, reinforcing their contributory role, albeit less strongly than magnesium, in DPN progression. Overall, the cohort's distribution across severity categories revealed that advancing age and higher HbA1c values were each linked to more severe neuropathy, underscoring the interplay between ageing, glycaemic control, and neural damage. The combined analysis confirmed that electrolyte depletion, poor glycaemic control, and older age collectively align with increasing DPN severity, highlighting serum magnesium in particular as a promising predictive marker.

Discussion

This study involved a total of 80 subjects, out of which 50 were males and 30 were females. The mean age of the study population was 51.77 ± 11.1 years. Out of 80 patients, 17 patients had severe diabetic peripheral neuropathy, 25 patients had moderate neuropathy, 18 patients had mild neuropathy, and 20 patients had no neuropathy.

Present study showed a positive correlation between age and severity of diabetic peripheral neuropathy with a p value of < 0.001 which is significant statistically. It also showed a positive correlation that presence of diabetic peripheral neuropathy was associated with older age and as age increases the severity of DPN increases significantly with a p value of < 0.00. Mean value of age in mild DPN study group was 48.72±7.77, and 52.28±11.43 in group with moderate DPN and mean value was 60.35±12.13 in group with severe DPN which is statistically significant. This has a similarity with earlier study done by Fei Mao et al.[7] who concluded age can be considered as an independent risk factor for the development of diabetic neuropathy in type 2 DM patients and is associated with the incidence small and large nerve dysfunction. Whereas a study conducted by Mimi Omar et al. concluded that younger patients had more prevalence of peripheral neuropathy in their study population.[8]

In our study, male gender was found to have more prevalence of peripheral neuropathy when compared with female gender with a P value of 0.001 which is significant statistically. Here 50 males participated in the study, 13 males had severe neuropathy, 21 males had moderate neuropathy, and 9 males had mild neuropathy. Earlier study done by Chythra R Rao et al. showed the prevalence of peripheral neuropathy in type 2 diabetes where proportion of males affected by neuropathy was more than females, which was conflicting to findings by Bansal et al.[9] who have reported that there were no definite sex differences in their study. In our study equal proportion of females and males could not be taken, as

Journal of Chemical Health Risks
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JCHR (2025) 15(4), 2369-2375 | ISSN:2251-6727

our main aim is to check whether there is correlation between magnesium and phosphorus levels and severity of neuropathy.

In our study, HBA1C was also found to be a better predictor of severity of diabetic peripheral neuropathy with a p value of 0.001 which is statistically significant. Majority of patients with moderate and severe DPN had HbA1c from 9-11% and mild DPN people were seen to have HBA1C between 7-9% with mean HbA1c of 8.53%. These findings were similar to one of the earlier studies published by Jian-Bin Su et al.[10] who concluded that increased variability of HbA1c is closely associated with diabetic peripheral neuropathy in Type 2 DM patients.

In our study, we compared duration of diabetes with severity of diabetic peripheral neuropathy between study groups, most of the patients without diabetic neuropathy were seen in age group of five to ten years of duration of diabetes. Patients with mild and moderate neuropathy are seen with duration of diabetes of five to ten years. Mean duration of 8.11 years for mild diabetic peripheral neuropathy and for moderate neuropathy this was 10.60 years. Majority of severe DPN patients were seen to be having diabetes for more than fifteen years with mean duration of 17.06 years. Significant difference is seen statistically in relation to period of diabetes mellitus between the study group with a p value of < 0.001 and having a hazard ratio of 2.24. Here we have seen that prevalence of DPN was nearly doubled with an increase in diabetes duration from 5years to 5-10 years and longer the duration of DM, severe diabetic peripheral neuropathy was observed.

Surendra Darivemula et al[11] studied about prevalence and its associated determinants of diabetic peripheral neuropathy (DPN) in individuals having type-2 diabetes mellitus in rural south India[12], in which they have observed increase in duration of diabetes is significantly associated with peripheral neuropathy which was similar to our study. Study conducted by Mimi Omar et al[8] concluded that younger patients had more prevalence of peripheral neuropathy and shorter duration of diabetes in study population which is contrary to most of the studies published.[13]

In general, an AUC of 0.745 suggests that the ability of serum phosphorus at < 1.95mg/dl to predict patients with DPN and without DPN is acceptable and hazard ratio was calculated, which was 3.82 which means that patients with serum phosphorus at < 1.95 mg/dl had a risk developing severe DPN approximately 3.82 times higher compared to those with serum phosphorus at > 1.95 mg/dl and 95% confidence interval was found out to be 2.36 to 6.58 with a significant p value <0.001.[14] Many previous trials have established the association of serum magnesium and diabetic peripheral neuropathy, but there were not many studies to see the association between phosphorus and peripheral neuropathy. In our study we wanted to observe the correlation between serum magnesium, serum phosphorus and diabetic peripheral neuropathy. We found out that there was correlation of both serum magnesium and serum phosphorus with severity of DPN, which shows as serum magnesium and serum phosphorus decrease, there is increase in severity of neuropathy.[15]

Comparison of ROC curves of serum magnesium and serum phosphorus in our study showed that serum magnesium has an area under the curve of 0.806 and that for phosphorous area under the curve was 0.745 regarding severity of DPN, indicates that both had good predictive value for diabetic peripheral neuropathy.[16] Sensitivity and specificity were obtained for both magnesium and phosphorus, serum magnesium had a sensitivity of 85% and a specificity of 82% with a positive predictive value of 84%, and a negative predictive of 78 % and cut off obtained for magnesium was at 1.25 mg/dl and serum magnesium can be a considered as a good predictor of diabetic peripheral neuropathy.[17] Sensitivity and specificity of phosphorus was 79% and 75% respectively and a positive predictive value of 76 % and a negative predictive value of 72% and cut off obtained for phosphorus was 1.95 mg/dl and can be considered as fair predictor of diabetic peripheral neuropathy.

This study has several limitations. First, the relatively small sample size restricts the generalisability of the findings to the broader diabetic population. Second, the potential influence of co-morbid conditions on the severity of diabetic peripheral neuropathy could not be entirely excluded, introducing possible confounding effects. Third, identifying the most informative combination of clinical, electrophysiological, and biochemical variables will require larger cohorts and

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JCHR (2025) 15(4), 2369-2375 | ISSN:2251-6727

additional research to validate and refine predictive models. Finally, the absence of longitudinal follow-up precludes assessment of temporal changes in neuropathy severity and limits evaluation of long-term outcomes.

Conclusion

This study confirms a statistically significant inverse correlation between serum magnesium and phosphate levels and the severity of DPN. Magnesium emerges as a more reliable biochemical marker. Monitoring these electrolytes may improve early identification and management of neuropathic complications in diabetes.

References

1. World Health Organization (WHO). (2023). Diabetes. Retrieved from https://www.who.int/news-room/fact-sheets/detail/diabetes
2. Centers for Disease Control and Prevention (CDC). (2023). Type 2 Diabetes. Retrieved from https://www.cdc.gov/diabetes/basics/type2.html
3. American Diabetes Association. (2014). Diagnosis and classification of diabetes mellitus. Diabetes Care, 37(Supplement 1), S81–S90. https://doi.org/10.2337/dc14-S081
4. American Diabetes Association (ADA). (2023). Diabetic neuropathy. https://diabetes.org/diabetes/complications/neuropathy.
5. Yadav H, Yadav A, Ansari AM, Yadav P, Sharma M. A study of serum phosphorus level in patients with diabetes mellitus. Int J Adv Res. 2023;11(2):189–92.
6. Bril, V., & Perkins, B. A. (2002). Validation of the Toronto Clinical Scoring System for diabetic polyneuropathy. Diabetes Care, 25(11), 2048–2052.
7. Fei Mao, Xiaoming Zhu, Siying Liu, Xiaona Qiao,Age as an Independent Risk Factor for Diabetic Peripheral Neuropathy in Chinese Patients with Type 2 Diabetes, Aging and disease, 2019, Vol. 10 Issue (3): 592-600.
8. Mimi, M Med et al, The Prevalence of Diabetic Peripheral Neuropathy in an outpatient Setting o Med, J Malaysia, Vol 58 No 4 October 2003.
9. Dipika Bansal et al, Prevalence and risk factors of development of peripheral diabetic neuropathy in type 2 diabetes mellitus in a tertiary care setting J Diabetes, Investig, 2014 Nov
10. Jian-bin Su et al, HbA1c variability and diabetic peripheral neuropathy in type 2 diabetic patients, Cardiovasc Diabetol. 2018; 17: 47
11. Surendra darivemula et al Prevalence and its associated determinants of Diabetic Peripheral Neuropathy (DPN) in individuals having type-2 diabetes mellitus in Rural South India. July 2019, Indian Journal of Community Medicine
12. Harati Y. Diabetes and the nervous system. Endocrinol Metab Clin North Am1996; 25(2):325-59.
13. Sonalika Gogia and Chythra R. Rao, Prevalence and Risk Factors for Peripheral Neuropathy among Type 2 Diabetes Mellitus Patients at a Tertiary Care Hospital in Coastal Karnataka, Indian J Endocrinol Metab. 2017 Sep-Oct; 21(5): 665–669.
14. Laakso M. Hyperglycemia and cardiovascular disease in type 2 diabetes. Diabetes. 1999; 48:937–942.
15. BuykenAE, vonEckardsteinA, SchulteH, et al. Type 2 diabetes mellitus and risk of coronary heart disease: results of the 10year follow-up of the PROCAM Study. Eur J Cardiovasc Prev Rehabil. 2007;14: 230–236.
16. Haffner SM, Lehto S, Ronnemaa T, et al. Mortality from coronary heart disease in subjects with type 2 diabetes and in nondiabetic subjects with and without prior myocardial infarction. N Engl J Med. 1998; 339:229–234.
17. Facchini FS, Hua N, Abbasi F, Reaven GM. Insulin resistance as a predictor of age-related diseases. J Clin Endocrinol Metab. 2001; 86:3574–3578.

Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(4), 2369-2375 | ISSN:2251-6727

Table 1: Baseline Characteristics of Study Population (N = 80)

Characteristics	Category	n (%)
Age (years) Mean ± SD (51.77 ± 11.1)	<30	1 (1.25)
	31–40	13 (16.25)
	41–50	28 (35)
	51–60	20 (25)
	>60	18 (22.5)
Gender	Male	50 (62.5)
	Female	30 (37.5)
Duration of Diabetes	≤5 years	16 (20)
	5–10 years	31 (38.75)
	11–15 years	16 (20)
	>15 years	17 (21.25)
HbA1c	>9	46 (57.5)
	≤9	34 (42.5)

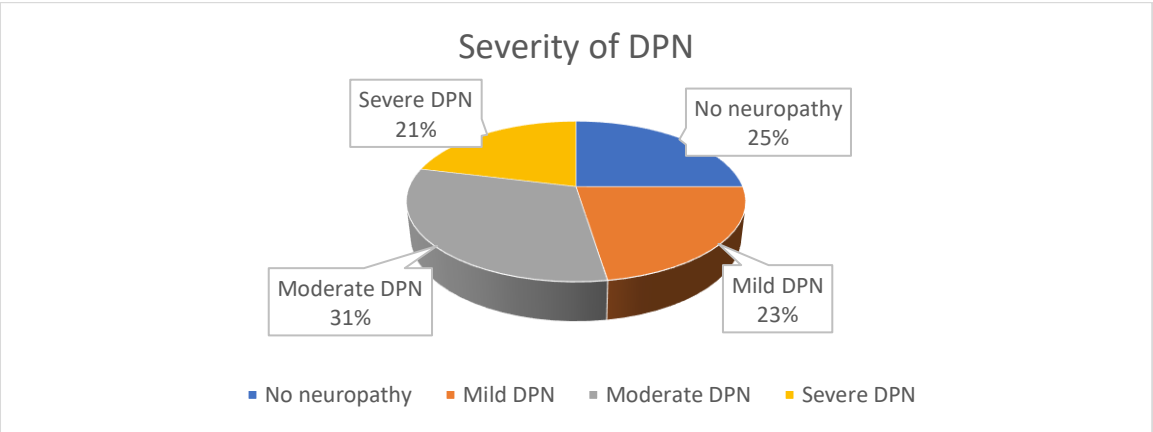

Figure 1: Severity Distribution of Diabetic Peripheral Neuropathy

Table 2: Various characteristics vs Severity of DPN

Severity		No neuropathy	Mild DPN	Moderate DPN	Severe DPN
Mean age (yrs)		46.60 (±8.34)	48.72 (±7.77)	52.28 (±11.43)	60.35 (±12.13) P value - 0.001
Gender	Male	35	50	84	76.5
	Female	65	50	16	23.5

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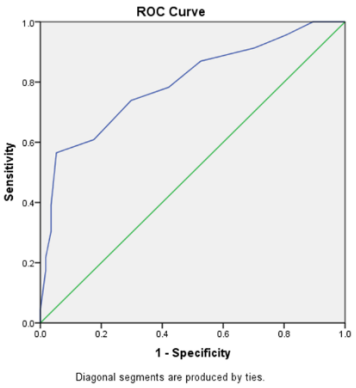
JCHR (2025) 15(4), 2369-2375 | ISSN:2251-6727

					P value – 0.003
Mean HbA1c %		8.10 (±1.29)	8.53 (±1.67)	10.18 (±2.19)	10.74 (±1.46) P value - <0.001
Mean Serum Mg (mg/dl) Mean ± SD		2.13 (± 0.21)	1.89 (± 0.27)	1.64 (± 0.21)	1.38 (± 0.17) P value – 0.001
Mean Serum P (mg/dl) Mean ± SD		3.91 (± 0.28)	3.67 (± 0.26)	3.49 (± 0.18)	3.13 (± 0.22) P value – 0.003

Association between magnesium levels and severity of DPN



Association between serum phosphorus levels and severity of DPN

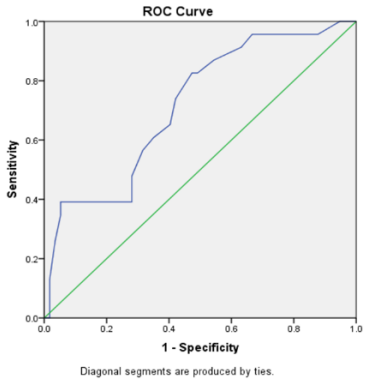


Figure 2: Receiver operating curve analysis

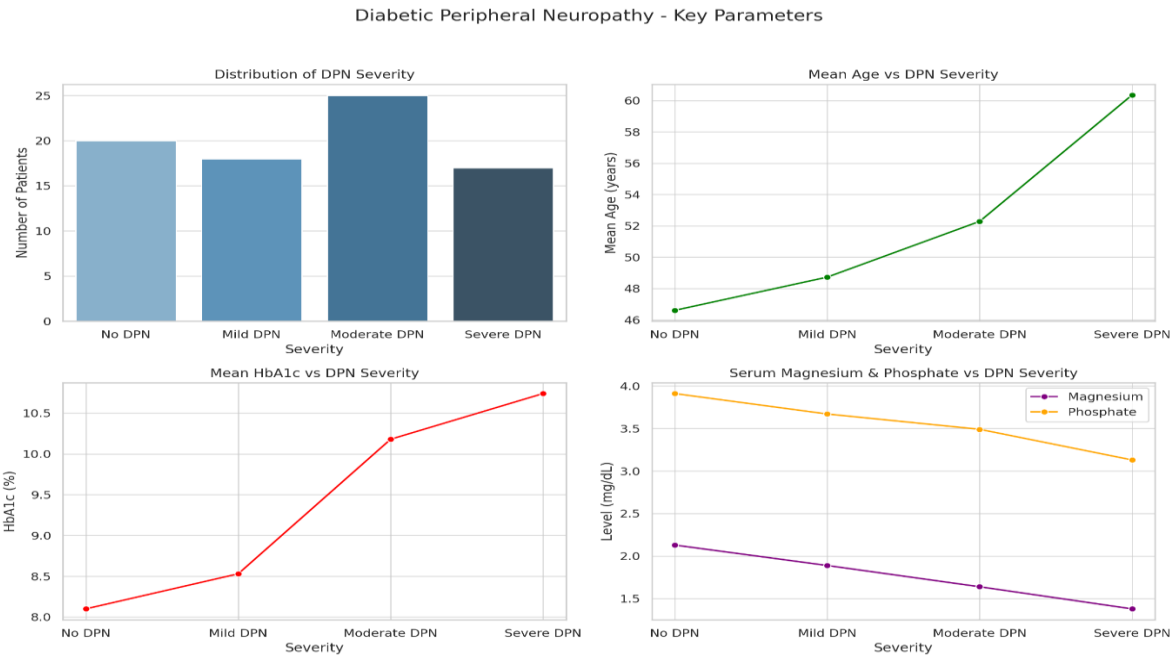


Figure 3: Key charts for visualizing the parameters