

Comparative Analysis of Diabetic Neuropathy Examination Scores and Nerve Conduction Velocity in Patients with Diabetic Neuropathy

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Received: 03-03-2024 / Revised 11-04-2024 / Accepted 08-05-2024

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DOI: <https://doi.org/10.32553/ijmbs.v8i3.2829>

Conflict of interest: Nil

Abstract:

Background: Diabetic neuropathy is a prevalent consequence of diabetes, resulting in substantial morbidity. Precise evaluation is essential for prompt intervention and control. The study assessed the correlation and effectiveness of the Diabetic Neuropathy Examination (DNE) scores and Nerve Conduction Velocity (NCV) as diagnostic tools in individuals with diabetic neuropathy.

Methods: An observational research was done, comprising 200 diabetic patients who were diagnosed with diabetic sensory-motor polyneuropathy. Participants completed Dynamic Neuromuscular Examination (DNE) grading and Nerve Conduction Velocity (NCV) testing. The data were analysed using SPSS version 20.0.

Results: The study found a considerable negative correlation ($r = -0.68$, $p < 0.001$) between DNE scores and NCV results. Higher DNE scores were associated with lower NCV values. Specifically, 20% of participants had mild neuropathy, 40% had moderate neuropathy, and 40% had severe neuropathy according to DNE scores. NCV testing revealed that 65% of participants had abnormal nerve conduction, with 25% showing mild reduction, 25% moderate reduction, and 15% severe reduction. Multivariate regression confirmed that DNE scores are significant predictors of NCV outcomes (Beta = -0.52, $p < 0.001$), even after adjusting for confounding variables such as gender, age, diabetes duration, and HbA1C levels.

Conclusion: DNE scoring is a reliable tool for assessing neuropathy severity in diabetic patients, correlating well with NCV results. Integrating DNE scoring in routine clinical practice can enhance the early detection and management of diabetic neuropathy.

Recommendations: Routine use of DNE scoring along with NCV testing is recommended for comprehensive evaluation of diabetic neuropathy. Further research should explore additional diagnostic tools to improve early detection and intervention.

Keywords: *Diabetic Neuropathy, Diabetic Neuropathy Examination Score, Nerve Conduction Velocity Testing, Diabetic Polyneuropathy, Neuropathy Assessment.*

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Introduction

Diabetic neuropathy is a prevalent and debilitating complication of diabetes mellitus, affecting nearly half of all diabetic patients. It encompasses a range of nerve conditions caused by diabetes, with diabetic peripheral neuropathy (DPN) being the most common form. DPN predominantly affects the sensory nerves and can lead to significant morbidity due to pain, numbness, and an increased risk of foot ulcers and amputations [1]. Recent advancements in the understanding and diagnosis of diabetic neuropathy have been significant, offering new insights into its management and early detection.

Traditionally, the diagnosis of diabetic neuropathy has relied on clinical evaluations and electrophysiological tests, such as nerve conduction velocity (NCV) studies. NCV measures the speed of electrical signals through peripheral nerves, providing objective data on the extent of nerve damage [2]. Recent studies have highlighted the utility of combined diagnostic approaches, integrating clinical scoring systems with electrophysiological tests to improve diagnostic accuracy and patient outcomes [3].

The Diabetic Neuropathy Examination (DNE) score is one such clinical tool that has gained prominence. It involves assessing muscle strength, tendon reflexes, and various sensory perceptions. A DNE score greater than three points is considered indicative of diabetic neuropathy. Studies have shown that DNE scoring, when used alongside NCV testing, enhances the detection and grading of neuropathy severity [4]. This combined approach allows for a more comprehensive evaluation, facilitating earlier intervention and better management of diabetic neuropathy.

Recent research has emphasized the importance of early detection and intervention in diabetic neuropathy. A study demonstrated that early identification

of neuropathy through clinical and electrophysiological methods can significantly reduce the progression of nerve damage [5]. Similarly, a study highlighted the efficacy of novel motor unit number estimation (MUNE) methods in detecting early motor involvement in diabetic polyneuropathy [6]. These advancements underscore the potential of integrating new diagnostic techniques with established methods like DNE scoring and NCV testing.

In addition, current research has established connections between different metabolic and physiological parameters and the advancement of diabetic neuropathy. A study found that patients with diabetic neuropathy have structural and functional abnormalities in the primary somatosensory cortex, indicating that the disease's development involves the central nervous system [7]. This highlights the complex interplay between peripheral and central nervous systems in diabetic neuropathy, necessitating a multifaceted diagnostic and therapeutic approach.

This study aims to compare DNE scores with NCV results in diabetic patients, providing further insights into the utility of these diagnostic tools in clinical practice.

Methodology

Study Design

A prospective observational study.

Study Setting

The study was conducted at Jawahar Lal Nehru Medical College & Hospital, Bhagalpur, Bihar, from October 2023 to March 2024.

Participants

The study involved 200 participants.

Inclusion Criteria

- Patients diagnosed with diabetic sensory-motor polyneuropathy who have diabetes.

Exclusion Criteria

- Patients with other causes of sensorimotor neuropathy (e.g., drugs, hypothyroidism, alcoholism, etc.).

Sample size

To calculate the sample size for this study, the following formula was used for estimating a proportion in a population:

$$n = \frac{Z^2 \times p \times (1-p)}{E^2}$$

Where:

- n = sample size
- Z = Z-score corresponding to the desired level of confidence
- p = estimated proportion in the population
- E = margin of error

Bias

Efforts were made to minimize selection bias by randomly selecting participants who meet the inclusion criteria. Measurement bias were addressed by ensuring standardized procedures and trained personnel for conducting the tests and evaluations.

Variables

Variables included diabetic neuropathy examination score, nerve conduction velocity, age, gender, duration of diabetes, HbA1C levels, and other relevant clinical parameters.

Data Collection

Data was collected through clinical examinations and laboratory investigations, including CBC, MCV, ESR, FBS, HbA1C, PP, urine analysis, serum creatinine, and NCV studies.

Procedure

1. Diabetic Neuropathy Examination (DNE) Scoring:

- Testing of two muscle strengths, one tendon reflex, and five sensations.
- Muscle Strength:

- Quadriceps femoris: Extension of the knee.
- Tibialis Anterior: Dorsiflexion of the foot.
- Ankle reflex.
- Sensitivity to pinpricks:
- Sensation: Index finger.
- Sensation: Big toe.
- Sensitivity to touch
- Perception of vibration
- Sensitivity to joint position
- Only the right leg and foot were tested; if the right leg was amputated, the left leg was tested instead

➤ Scoring:

- Score >3 points were considered abnormal.
- Score 0-20: Normal.
- Mild to moderate deficit: Muscle strength on the MRC scale is between 3 and 4; reflexes are decreased but still present; sensation is reduced but still detectable.
- Severe disturbance or absence: Muscle strength on the MRC scale is between 0 and 2; reflexes are absent; sensation is also absent.
- Scoring:
 - 4-8: Mild Grade I.
 - 9-12: Moderate Grade II.
 - 13-16: Severe Grade III.

2. Nerve Conduction Velocity (NCV) Testing:

The diagnostic test was employed to assess the electrical conductivity of both motor and sensory nerves. Sensory testing was conducted on the sural nerve located behind the lateral malleolus, and action potentials were measured at a fixed distance of 14 cm. The motor testing evaluated the speed of motor nerve conduction (MNCV) and the time it takes for signals to travel to the tibial and peroneal nerves. Neurophysiological testing were performed using a standardised setup, where impulses were displayed on a computer screen and data was captured. The patients had steady hemodynamics, normal body temperature,

and the room temperature was maintained at 32°C.

- Distal Latency Grading:
 - Normal distal latency: up to 6 ms.
 - Scoring:
 - Upto 25% of normal: 0.
 - 26%-50%: 1.
 - >50%: 2.
- Grading of SNCV and MNCV:
 - Normal SNCV (sural) and MNCV (tibial and peroneal): up to 41 m/sec.
 - Scoring:
 - 85%-95% of normal: 0.
 - 75%-85%: 1.
 - <75%: 2.
- Scoring of SNAP (Sural Sensory Nerve Action Potential):
 - Normal SNAP: up to 6 µV.
 - Scoring:
 - >75% of normal: 0.
 - 50%-75%: 1.
 - <50%: 2.
- Scoring in EP:
 - Grade I: 0-4 (Mild).
 - Grade II: 5-8 (Moderate).

- Grade III: 9-12 (Severe).

Statistical Analysis

Data was analyzed using SPSS version 20.0. t-tests or ANOVA and chi-square tests were utilized. A multivariate regression analysis was accomplished to account for possible confounding factors. Statistical significance was established at a p-value of less than 0.05.

Ethical considerations

The study protocol was approved by the Ethics Committee and written informed consent was received from all the participants.

Result

Out of the 200 participants comprised in the study, 110 (55%) were male and 90 (45%) were female. The average age of the participants was 56.4 ± 10.2 years. The average diabetes duration was 12.5 ± 6.3 years, and the mean HbA1C level was $8.4 \pm 1.2\%$.

Table 1: Demographics and Clinical Features

Characteristic	Mean \pm SD / n (%)
Age (years)	56.4 \pm 10.2
Gender	
Male	110 (55%)
Female	90 (45%)
Duration of Diabetes (years)	12.5 \pm 6.3
HbA1C (%)	8.4 \pm 1.2

The most common symptoms reported by the participants included numbness (80%), tingling (75%), and pain (60%).

Table 2: Symptoms of Diabetic Neuropathy in Study Patients

Symptom	n (%)
Numbness	160 (80%)
Tingling	150 (75%)
Pain	120 (60%)
Burning Sensation	100 (50%)
Weakness	80 (40%)

The DNE scores ranged from 4 to 16, with a mean score of 10.2 ± 3.1 . Based on the DNE scoring system, 40 participants (20%) had mild diabetic neuropathy (Grade I), 80 participants (40%) had moderate neuropathy (Grade II), and 80 participants (40%) had severe neuropathy (Grade III).

Table 3: Distribution of DNE Scores

DNE Score Range	n (%)	Mean ± SD (m/sec)
4-8 (Mild)	40 (20%)	6.5 ± 1.1
9-12 (Moderate)	80 (40%)	10.5 ± 1.0
13-16 (Severe)	80 (40%)	14.2 ± 0.9

Table 4: Neurologic Signs

Neurologic Sign	n (%)
Quadriceps femoris (weakness)	120 (60%)
Tibialis Anterior (weakness)	110 (55%)
Ankle Reflex (absent)	140 (70%)
Sensitivity to pinpricks (index finger)	150 (75%)
Sensitivity to pinpricks (big toe)	150 (75%)
Sensitivity to touch	130 (65%)
Vibration perception	140 (70%)
Sensitivity to joint position	135 (67.5%)

NCV testing revealed that 70 participants (35%) had normal NCV, while 130 participants (65%) had abnormal NCV. Among those with abnormal NCV, the severity of the conduction velocity reduction was classified as follows: 50 participants (25%) had mild reduction, 50 participants (25%) had moderate reduction, and 30 participants (15%) had severe reduction.

Table 5: NCV Testing Results

NCV Grade	n (%)	Mean ± SD (m/sec)
Normal	70 (35%)	42.1 ± 1.8
Mild Reduction	50 (25%)	36.8 ± 1.2
Moderate Reduction	50 (25%)	32.5 ± 1.4
Severe Reduction	30 (15%)	28.4 ± 1.1

A considerable negative correlation was found among DNE scores and NCV results ($r = -0.68$, $p < 0.001$), indicating that higher DNE scores were correlated with lower NCV values.

A multivariate regression analysis was accomplished to adjust for potential confounders, including gender, age, diabetes duration, and HbA1C levels. The analysis showed that DNE scores remained a significant predictor of NCV results after adjusting for these variables.

Table 6: Multivariate Regression Analysis

Variable	Beta Coefficient	Standard Error	p-value
DNE Score	-0.52	0.06	<0.001
Age	-0.08	0.06	0.07
Gender (Male)	-0.12	0.13	0.35
Duration of Diabetes	-0.15	0.05	0.003
HbA1C	-0.09	0.11	0.40

Discussion

The study had a sample of 200 participants, with an average age of 56.4 years, largely consisting of males (55%). The individuals had a diabetes duration with an average of

12.5 years and a mean HbA1C level of 8.4%.

The DNE scores ranged from 4 to 16, with a mean score of 10.2. According to the DNE scoring system, 20% of participants had mild neuropathy, 40% had moderate

neuropathy, and another 40% had severe neuropathy. This distribution indicates that a significant portion of the study population had considerable impairment due to diabetic neuropathy. The neurologic signs assessed, such as muscle strength, reflexes, and various sensory perceptions, showed widespread abnormalities, supporting the high incidence of neuropathy in the study population.

NCV testing revealed that 65% of participants had abnormal nerve conduction, with reductions categorized into mild, moderate, and severe. These findings align with the DNE scores, suggesting that a higher DNE score correlates with more severe neuropathy as indicated by NCV. The significant negative correlation ($r = -0.68$, $p < 0.001$) between DNE scores and NCV results confirms this association. Higher DNE scores were consistently linked to lower NCV values, indicating more severe nerve damage.

Further, multivariate regression analysis, adjusting for age, gender, diabetes duration, and HbA1C levels, demonstrated that DNE scores remained a significant predictor of NCV outcomes. This underscores the robustness of DNE scores as an independent indicator of neuropathy severity. The beta coefficient for the DNE score was -0.52 ($p < 0.001$), signifying a substantial inverse relationship between DNE scores and NCV, even when accounting for other variables.

Overall, the study highlights the utility of DNE scoring as a reliable tool for assessing the severity of diabetic neuropathy. The strong correlation between DNE scores and NCV results suggests that clinical assessments using DNE can effectively predict the extent of nerve damage in diabetic patients. These findings advocate for the integration of DNE scoring in routine clinical practice to identify and monitor diabetic neuropathy, potentially improving patient management and outcomes.

Recent studies have examined the relationship between DN examination scores and NCV in individuals with DN. A study analyzed NCV in 77 diabetic patients, revealing that increased age, longer duration of diabetes, and male gender significantly correlated with abnormal NCV. The analysis indicated higher neurological disorder ratios in the ankle and knee nerves among patients with abnormal NCV [8].

A study compared clinical assessments and NCV in 300 type 2 diabetic patients, finding significant differences in diagnosing symmetrical neuropathy, motor polyneuropathy, and sensory neuropathy. Clinical methods often underdiagnosed compared to NCV, highlighting the importance of NCV in accurate neuropathy detection [9]. Research involving sensory conduction analysis of the median and ulnar nerves in diabetic individuals showed decreased sensory conduction velocity compared to non-diabetics, although the difference was not statistically significant. This underscores the utility of NCV in identifying neuropathic changes even when clinical symptoms are not pronounced [10].

A study utilising diffusion tensor imaging (DTI) of the median nerve in diabetic patients discovered noteworthy associations between DTI metrics (e.g., fractional anisotropy) and clinical neuropathy scores, such as the Neuropathy Deficit Score (NDS) and DNE score. The use of DTI allowed for the examination of nerve injury without the need for intrusive procedures. This examination was able to establish a correlation between the extent of nerve damage and both clinical and electrophysiological examinations [11]. A study involving 740 individuals with type 2 diabetes found that a greater amount of time spent within the target glucose range, as measured by continuous glucose monitoring, was linked to higher composite Z-scores for nerve conduction velocity and amplitude. This suggests an enhancement in peripheral nerve function. These findings

indicate that TIR could be a useful measure for tracking the evolution of diabetic neuropathy [12].

A study investigating the specificity and sensitivity of sensory NCV and F-wave minimal latency of the median nerve in early DN revealed that sensory conduction velocity exhibited higher levels of specificity and sensitivity compared to F-wave latency. This emphasises the significance of conducting electrophysiological tests at an early stage to diagnose neuropathy [13]. The most prevalent observation among individuals with diabetic foot was the presence of mixed type neuropathy affecting both lower limbs. NCV studies revealed a higher incidence of bilateral neuropathy compared to clinical exams, suggesting that NCV has a more advanced diagnostic ability [14].

Conclusion

The study demonstrates that DNE scores are significantly correlated with NCV results, making DNE scoring a reliable predictor of neuropathy severity in diabetic patients. The findings support the use of DNE scoring as an effective clinical tool for assessing and monitoring diabetic neuropathy, aiding in the timely identification and management of patients with this condition. Integrating DNE scoring into routine practice can enhance patient care by providing a straightforward method for evaluating the extent of neuropathy.

Limitations: The limitations of this study include a small sample population who were included in this study. Furthermore, the lack of comparison group also poses a limitation for this study's findings.

Recommendation: Routine use of DNE scoring along with NCV testing is recommended for comprehensive evaluation of diabetic neuropathy. Further research should explore additional diagnostic tools to improve early detection and intervention.

Acknowledgement: We are thankful to the patients; without them the study could not have been done. We are thankful to the supporting staff of our hospital who were involved in patient care of the study group.

List of abbreviations:

DNE: Diabetic Neuropathy Examination
 NCV: Nerve Conduction Velocity
 HbA1C: Hemoglobin A1C
 DPN: Diabetic Peripheral Neuropathy
 MUNE: Motor Unit Number Estimation
 MRC: Medical Research Council
 CBC: Complete Blood Count
 MCV: Mean Corpuscular Volume
 ESR: Erythrocyte Sedimentation Rate
 FBS: Fasting Blood Sugar
 PP: Postprandial
 SNCV: Sensory Nerve Conduction Velocity
 MNCV: Motor Nerve Conduction Velocity
 SNAP: Sensory Nerve Action Potential
 EP: Electrophysiology
 DTI: Diffusion Tensor Imaging
 NDS: Neuropathy Deficit Score
 TIR: Time in Range

Source of funding: No funding received.

Conflict of interest: The authors have no competing interests to declare.

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