

Association of Peripheral Neuropathy with Regional Plantar-Pressure Patterns in Patients with Type 2 Diabetes Mellitus

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ABSTRACT

Introduction: Diabetic peripheral neuropathy and altered plantar loading are important contributors to diabetic-foot complications in patients with Type 2 Diabetes Mellitus (T2DM). Vibration perception threshold (VPT) provides a quantitative assessment of sensory dysfunction, while plantar-pressure mapping identifies regional loading abnormalities. Aim of the study was to assess peripheral neuropathy using VPT, describe regional plantar-pressure patterns, and evaluate their association with glycaemic parameters and high/very-high plantar loading in patients with T2DM. **Material and Methods:** A retrospective cross-sectional study was conducted using records of 71 patients with T2DM. Right and left VPT values, VPT severity, regional plantar-pressure categories, fasting blood sugar (FBS), post-prandial blood sugar (PPBS), HbA1c, age, and gender were analyzed. Appropriate available-case analyses, group comparisons, and Spearman correlation tests were performed. **Results:** Among 65 patients with evaluable VPT data, 55.4% had severe neuropathy based on maximum VPT severity. Mean right and left VPT values were 25.1 ± 13.6 V and 24.4 ± 13.6 V, respectively, with strong bilateral correlation ($\rho=0.890$, $p<0.001$). Very-high plantar loading was most frequent in the forefoot. Age showed a significant positive correlation with mean VPT ($\rho=0.303$, $p=0.017$). FBS, PPBS, HbA1c, and regional plantar-pressure severity showed no significant correlations with VPT. **Conclusion:** Peripheral neuropathy and elevated plantar loading were common, but their severity did not significantly correlate, suggesting that neurological and biomechanical assessments provide complementary information in diabetic-foot risk evaluation.

Keywords: Type 2 Diabetes Mellitus; diabetic peripheral neuropathy; vibration perception threshold; biothesiometry; plantar pressure; HbA1c.

INTRODUCTION

Diabetes-related foot disease is one of the most disabling complications of Type 2 Diabetes Mellitus (T2DM), resulting from the complex interaction of peripheral neuropathy, repetitive mechanical loading, foot deformity, vascular impairment, and reduced tissue resilience. Diabetic peripheral neuropathy (DPN) produces progressive sensory dysfunction and loss of protective sensation, allowing repetitive minor trauma to occur without appropriate pain perception. When combined with abnormal plantar loading, this may contribute to callus formation, tissue breakdown,

ulceration, infection, and ultimately lower-limb amputation. Contemporary reviews and the International Working Group on the Diabetic Foot (IWGDF) guidelines therefore emphasize identification of neuropathy and abnormal mechanical loading as essential components of diabetic-foot risk assessment and prevention [1–3].

Vibration perception threshold (VPT), commonly measured using a biothesiometer, provides an objective quantitative assessment of large-fibre sensory dysfunction and is increasingly used to identify and grade diabetic peripheral neuropathy. Solanki et al., in an

Indian cross-sectional study of patients with T2DM, demonstrated a substantial prevalence of VPT-defined neuropathy and reported relationships between VPT abnormality and indices of glycaemic control, supporting the clinical utility of quantitative vibration assessment [4]. Dong et al., in a large multicentre study, further demonstrated that increasing VPT was associated with altered gait characteristics, including increased step time and gait variability, suggesting that progressive sensory dysfunction may also translate into clinically relevant biomechanical changes [5].

Plantar-pressure distribution represents another important biomechanical component of diabetic-foot risk. Peripheral neuropathy may alter muscle function, joint mobility, gait, and load transfer across the foot, leading to abnormal pressure concentrations at vulnerable regions. Cao et al. demonstrated significantly increased forefoot peak pressures among patients with DPN, with or without peripheral arterial disease [6]. Jorgetto et al. similarly reported altered dynamic plantar pressures and biomechanical abnormalities among individuals with peripheral diabetic neuropathy [7]. In an Indian comparative study, Totaganti et al. observed significantly greater dynamic maximum plantar pressures in patients with diabetic neuropathy than in those without neuropathy, particularly at the first metatarsal and midfoot regions; poor glycaemic control was also associated with increased pressure at selected plantar sites [8].

The relationship between sensory loss and mechanical loading, however, is not necessarily linear. Monteiro et al. demonstrated that plantar skin mechanical characteristics combined with impaired vibration perception could contribute to prediction of forefoot loading, highlighting the multifactorial nature of plantar-pressure abnormalities [9]. Thus, VPT and plantar-pressure assessment represent related but biologically distinct dimensions of diabetic-foot risk.

Despite these studies, an important research gap remains. Recent investigations have commonly evaluated VPT, gait, plantar pressure, or glycaemic control separately, while studies integrating VPT-defined neuropathy, bilateral regional plantar-pressure patterns, and routine glycaemic parameters within the same clinical population remain limited, particularly in Indian patients with T2DM. Moreover, most biomechanical studies have employed specialized platforms yielding quantitative pressure measurements, whereas real-world diabetic-foot reports may provide clinically categorized regional loading patterns. Whether worsening peripheral sensory dysfunction consistently corresponds with high or very-high regional plantar loading therefore remains uncertain.

Accordingly, the present study aims to characterize peripheral neuropathy using right- and left-foot VPT

values and device-reported severity grades, describe plantar-pressure patterns across the forefoot, midfoot, and heel, and evaluate the association between abnormal VPT and high/very-high regional plantar-pressure loading in patients with T2DM. Secondary analyses will examine the relationships of VPT with FBS, PPBS, HbA1c, age, sex, bilateral VPT differences, and the number of high-pressure regions. Such a multimodal assessment may clarify whether neurological, biomechanical, and glycaemic measures provide concordant or complementary information for diabetic-foot risk stratification.

MATERIALS AND METHODS

This was a retrospective, observational, cross-sectional, record-based study conducted in the Departments of Endocrinology and General Medicine, NRI General and Superspeciality Hospital, Mangalagiri. The study included patients with documented Type 2 Diabetes Mellitus who had undergone diabetic-foot assessment with digital biothesiometry/vibration perception threshold (VPT) testing and/or plantar-pressure mapping. Existing clinical records, diabetic-foot assessment reports, and available laboratory investigations were reviewed without performing any additional diagnostic test or intervention.

Study Population and Sample Size

A census sampling method was adopted because the study was based on a finite set of existing clinical records. All eligible unique patient records available during the study period were included. The finalized master dataset consisted of 71 unique patients. As all investigations were not available for every participant, analyses of VPT, plantar pressure, FBS, PPBS, and HbA1c were carried out using variable-specific available-case denominators.

Inclusion Criteria

- Patients aged 18 years and above.
- Patients with documented Type 2 Diabetes Mellitus in the institutional clinical record.
- Availability of at least one interpretable diabetic-foot assessment report containing digital biothesiometry/VPT and/or plantar-pressure mapping.
- Availability of sufficient patient identifiers to consolidate repeated reports at the patient level and avoid duplicate counting.

Exclusion Criteria

- Patients with Type 1 Diabetes Mellitus or gestational diabetes mellitus.
- Records in which the diagnosis of Type 2 Diabetes Mellitus could not be confirmed.

- Records that could not be reliably linked to a unique patient after review of available identifiers.
- Technically unreadable, incomplete, or non-interpretable VPT/biothesiometry reports for VPT-related analyses.
- Technically unreadable or non-interpretable plantar-pressure maps for plantar-pressure-related analyses.
- Records with insufficient clinical information to determine eligibility for the study.

Study Tool

A structured case record/data-extraction form was used to collect the required study variables from the available records. The form included demographic details, clinical information, glycaemic parameters, VPT findings, and regional plantar-pressure findings. VPT values were recorded separately for the right and left feet along with the device-reported severity grades of Normal, Mild, Moderate, or Severe. Plantar-pressure findings were documented separately for the forefoot, midfoot, and heel of both feet using the report categories Less, Normal, Mild, High, and Very High.

Data Collection

- Demographic information including age and gender was recorded from the available clinical records.
- Clinical details such as duration of Type 2 Diabetes Mellitus, current treatment, history of

diabetic-foot ulcer, and presence of peripheral neuropathy were documented when available.

- Available glycaemic parameters including FBS, PPBS, and HbA1c were collected from the corresponding laboratory/clinical records.
- Right- and left-foot VPT values and device-reported severity grades were recorded.
- Overall VPT status was classified as normal or abnormal, and the maximum VPT severity was documented.
- Regional plantar-pressure categories were recorded separately for the forefoot, midfoot, and heel of each foot.
- Presence of High/Very-high plantar-pressure loading and the number of such regions were documented.
- Duplicate records were identified and consolidated so that each patient was counted only once.

Statistical Analysis

The collected data were entered into Microsoft Excel and summarized using appropriate descriptive statistics, tables, graphs, frequencies, and percentages. Descriptive analyses, group comparisons, and correlation analyses were performed using the available-case denominator for each variable. Categorical associations were assessed using appropriate tests of significance, including the Chi-square test where applicable. A p-value <0.05 was considered statistically significant.

RESULTS

Table 1. Demographic, Glycaemic and Clinical Assessment Profile of the Study Population

Parameter	Available (n)	Result
Total participants	71	71
Age, years, Mean $\pm$ SD	68	53.3 $\pm$ 11.4
Age, years, Median (IQR)	68	52.0 (47.0–60.5)
Male	70	35 (50.0%)
Female	70	35 (50.0%)
FBS, mg/dL, Mean $\pm$ SD	36	165.6 $\pm$ 66.6
PPBS, mg/dL, Mean $\pm$ SD	32	226.8 $\pm$ 72.1
HbA1c, %, Mean $\pm$ SD	16	9.16 $\pm$ 1.69
VPT assessment available	71	65 (91.5%)
Plantar-pressure assessment available	71	64 (90.1%)

The study included 71 patients with Type 2 Diabetes Mellitus with a mean age of 53.3 $\pm$ 11.4 years, and males and females were equally represented among participants with available gender data. Glycaemic parameters demonstrated considerable variability, with mean FBS of 165.6 mg/dL, mean PPBS of 226.8 mg/dL and mean HbA1c of 9.16%. VPT assessment was available in 91.5% of participants and plantar-pressure assessment in approximately 90%. Since laboratory parameters were not available for all patients, glycaemic analyses were performed using available-case denominators.

Table 2. Distribution of Vibration Perception Threshold and Peripheral Neuropathy Severity

VPT parameter	Right Foot n (%)	Left Foot n (%)
Participants assessed	65	65
VPT, Mean $\pm$ SD (V)	25.1 $\pm$ 13.6	24.4 $\pm$ 13.6
VPT, Median (IQR) (V)	26 (12–36)	24 (13–36)
Normal	25 (38.5)	23 (35.4)
Mild	4 (6.2)	6 (9.2)
Moderate	3 (4.6)	10 (15.4)
Severe	33 (50.8)	26 (40.0)

Maximum VPT Severity across Either Foot

Maximum VPT severity	n (%)
Normal	20 (30.8)
Mild	5 (7.7)
Moderate	4 (6.2)
Severe	36 (55.4)
Total	65 (100)

Right vs left VPT: Wilcoxon signed-rank test, **p = 0.175.**

Correlation between right and left VPT: Spearman ρ = **0.890**, **p < 0.001.**

More than half of the participants with VPT data had severe neuropathy when the worse VPT severity of either foot was considered, with 55.4% classified as severe. Severe VPT abnormality was more frequently observed in the right foot than the left foot. There was no statistically significant difference between right- and left-foot VPT values. However, a very strong positive correlation existed between right- and left-foot VPT values, indicating substantial bilateral correspondence in sensory dysfunction.

Table 3. Regional Distribution of Plantar-Pressure Categories

Region	Less n (%)	Normal n (%)	Mild n (%)	High n (%)	Very High n (%)
Left forefoot (n=64)	1 (1.6)	6 (9.4)	5 (7.8)	21 (32.8)	31 (48.4)
Left midfoot (n=64)	1 (1.6)	9 (14.1)	28 (43.8)	13 (20.3)	13 (20.3)
Left heel (n=64)	1 (1.6)	13 (20.3)	15 (23.4)	15 (23.4)	20 (31.2)
Right forefoot (n=60)	1 (1.7)	4 (6.7)	10 (16.7)	19 (31.7)	26 (43.3)
Right midfoot (n=60)	0	11 (18.3)	30 (50.0)	16 (26.7)	3 (5.0)
Right heel (n=60)	0	9 (15.0)	12 (20.0)	17 (28.3)	22 (36.7)

Regional plantar-pressure assessment demonstrated considerable heterogeneity across different regions of the foot. Very-high pressure was most frequently detected in the forefoot, affecting 48.4% of left forefeet and 43.3% of right forefeet. The midfoot predominantly demonstrated mild pressure loading, whereas high and very-high loading was also common in the heel regions. These findings indicate that the forefoot represents an important site of elevated plantar loading in patients with Type 2 Diabetes Mellitus.

Table 4. Association Between VPT Status and High/Very-High Regional Plantar-Pressure Loading
Abnormal VPT = Mild, Moderate or Severe maximum VPT grade.

Plantar region	Normal VPT High/Very High n/N (%)	Abnormal VPT High/Very High n/N (%)	Odds Ratio (95% CI)	p-value*
Left forefoot	13/17 (76.5)	34/42 (81.0)	1.31 (0.34–5.09)	0.729
Left midfoot	8/17 (47.1)	16/42 (38.1)	0.69 (0.22–2.16)	0.569
Left heel	7/17 (41.2)	26/42 (61.9)	2.32 (0.74–7.33)	0.162
Right forefoot	11/17 (64.7)	30/38 (78.9)	2.05 (0.58–7.24)	0.322
Right midfoot	4/17 (23.5)	13/38 (34.2)	1.69 (0.46–6.24)	0.536
Right heel	9/17 (52.9)	27/38 (71.1)	2.18 (0.67–7.12)	0.229

*Fisher's exact test.

Participants with abnormal VPT demonstrated numerically higher proportions of high/very-high plantar loading at the left heel, right forefoot, right midfoot and right heel compared with those with normal VPT. The largest relative differences were observed at the left and right heel regions. However, none of the regional associations reached statistical significance. These findings suggest that peripheral sensory dysfunction and plantar-pressure loading may represent related but not necessarily directly proportional components of diabetic-foot risk.

Table 5. Comparison of Demographic and Glycaemic Parameters Between Normal and Abnormal VPT Groups

Parameter	Normal VPT	Abnormal VPT	p-value
Age, years, Median (IQR)	51.5 (43.5–55.0), n=18	55.0 (48.0–62.5), n=44	0.174
Male gender	9/20 (45.0%)	22/44 (50.0%)	0.791
FBS, mg/dL, Median (IQR)	141 (136.5–155), n=11	165 (123–203), n=23	0.113
PPBS, mg/dL, Median (IQR)	210 (202.5–234), n=11	243 (162.5–278), n=19	0.931
HbA1c, %, Median (IQR)	8.5 (7.75–9.58), n=8	9.8 (9.30–10.40), n=7	0.246

Patients with abnormal VPT tended to be older and demonstrated higher median FBS and HbA1c levels compared with patients with normal VPT. Median HbA1c was 9.8% in the abnormal VPT group compared with 8.5% in the normal group. Nevertheless, none of these differences reached statistical significance. The relatively small available sample for HbA1c and other glycaemic variables should be considered when interpreting these findings.

Table 6. Correlation of Age and Glycaemic Parameters With Mean Bilateral VPT

Parameter	n	Spearman correlation coefficient (ρ)	p-value
Age	62	0.303	0.017
FBS	34	0.254	0.147
PPBS	30	–0.045	0.814
HbA1c	15	0.183	0.514

Age demonstrated a statistically significant positive correlation with mean bilateral VPT ($\rho = 0.303$, $p = 0.017$), indicating that increasing age was associated with increasing vibration perception threshold and greater sensory dysfunction. FBS showed a weak positive correlation with VPT, whereas HbA1c also showed a weak positive association; however, neither reached statistical significance. PPBS showed virtually no correlation with VPT. Glycaemic correlations should be interpreted cautiously because laboratory values were available only in subsets of the study population.

Table 7. Correlation Between VPT and Regional Plantar-Pressure Severity

For this exploratory analysis, plantar-pressure categories were treated as ordinal variables:

Less = 0, Normal = 1, Mild = 2, High = 3 and Very High = 4.

Plantar-pressure parameter	n	Spearman ρ with Mean VPT	p-value
Left forefoot	59	–0.144	0.276
Left midfoot	59	–0.029	0.826
Left heel	59	–0.030	0.819
Right forefoot	55	–0.200	0.143
Right midfoot	55	0.064	0.641
Right heel	55	0.015	0.913
Composite six-region plantar-pressure score	55	–0.074	0.591
Number of High/Very-high regions	55	–0.046	0.738

No statistically significant correlation was observed between mean VPT and plantar-pressure severity in any individual foot region. Similarly, neither the composite plantar-pressure score nor the total number of high/very-high pressure regions demonstrated a significant relationship with VPT. This suggests that the degree of vibration sensory impairment alone may not determine regional plantar-pressure loading and supports the concept that neuropathy and mechanical loading represent complementary dimensions of diabetic-foot risk.

DISCUSSION

The present study evaluated peripheral neuropathy, regional plantar-pressure patterns, and glycaemic parameters among patients with Type 2 Diabetes Mellitus using a multimodal diabetic-foot assessment approach. Among 65 participants with evaluable VPT data, 55.4% had severe neuropathy based on the maximum VPT severity grade, while only 30.8% had normal VPT. Mean VPT values were comparable between the right and left feet (25.1 ± 13.6 V and 24.4 ± 13.6 V, respectively), with no significant right-left difference ($p=0.175$). However, the strong correlation between right and left VPT (Spearman $\rho=0.890$, $p<0.001$) suggests that peripheral sensory impairment was largely bilateral. The clinical relevance of VPT assessment is supported by recent literature. Casadei et al. emphasized the potential relationship between glycaemic exposure and diabetic peripheral neuropathy [10], while Jung et al. demonstrated that impaired VPT was associated with poorer balance and that age contributed to functional impairment in patients with T2DM [11].

In the present study, age showed a significant positive correlation with mean bilateral VPT ($\rho=0.303$, $p=0.017$), indicating greater sensory impairment with advancing age. This is consistent with the findings of Jung et al. [11]. Chatrenet et al. additionally demonstrated that plantar-pressure distribution varies with the degree of peripheral neuropathy, but the changes were not simply proportional to neuropathy severity; mild neuropathy was associated with increased pressure around the anterior metatarsal region, whereas severe neuropathy showed a different spatial pattern [12]. This observation is relevant to the current findings because regional plantar loading also demonstrated considerable heterogeneity. Liu et al., using neurothesiometry in 421 patients with T2DM, confirmed the diagnostic usefulness of VPT for diabetic polyneuropathy, although their findings also highlighted that diagnostic thresholds vary according to the reference definition used [13].

Regional plantar-pressure analysis in the present study showed that very-high loading was particularly common in the forefoot, affecting 48.4% of left forefeet and 43.3% of right forefeet. High/very-high loading was also frequent in the heel, whereas mild loading predominated in the midfoot. The importance of considering pressure regionally is supported by Abbott et al., who demonstrated that elevated barefoot peak plantar pressure was strongly associated with previous diabetic foot ulceration at specific anatomical sites [14]. Importantly, however, the present study did not demonstrate a statistically significant association between abnormal VPT and high/very-high loading in any individual plantar region. Similarly, correlations

between mean VPT and the regional plantar-pressure categories, composite pressure score, and number of high/very-high regions were nonsignificant. These findings suggest that loss of vibration sensation alone may not determine the pattern or magnitude of plantar loading.

This lack of a direct relationship is biologically plausible because plantar loading is influenced by multiple factors including foot structure, joint mobility, gait characteristics, body weight, tissue properties, and neuropathy. Cheng et al. identified age and elevated HbA1c among significant predictors of DPN [15], while Nozawa et al. demonstrated that higher long-term mean HbA1c was associated with DPN in a large real-world cohort [16]. In contrast, the present study found only weak and nonsignificant correlations between VPT and FBS ($\rho=0.254$, $p=0.147$), PPBS ($\rho=-0.045$, $p=0.814$), and HbA1c ($\rho=0.183$, $p=0.514$). These results should not be interpreted as evidence against a role for glycaemic control because HbA1c was available in only 15 participants for correlation analysis, and a single contemporary laboratory value may not adequately represent cumulative glycaemic exposure.

Further evidence supports the concept that neuropathy and plantar loading are complementary rather than interchangeable risk dimensions. Bartolo et al. demonstrated that the pressure-time integral, reflecting both magnitude and duration of loading, discriminated neuropathic ulceration more effectively than peak plantar pressure alone [17]. Similarly, Khalil et al. reported elevated peak plantar pressure in 80% of patients with DPN compared with 65% without DPN, but this difference was not statistically significant ($p=0.288$), closely paralleling the nonsignificant VPT-pressure associations observed in the present study [18]. More recently, Lockhart et al. concluded that plantar-pressure measurement has considerable potential for diabetic-foot risk assessment, while emphasizing the need for standardized methods and larger real-world studies [19].

Strengths of the Study

1. **Multimodal assessment:** The study simultaneously evaluated peripheral neuropathy using bilateral vibration perception threshold (VPT), regional plantar-pressure patterns, and glycaemic parameters, providing a broader assessment of diabetic-foot risk.
2. **Bilateral and regional assessment:** VPT was assessed separately for both feet, while plantar pressure was evaluated across the forefoot, midfoot, and heel, allowing identification of region-specific loading patterns.
3. **Patient-level data consolidation:** Duplicate clinical records were identified and consolidated

to ensure that each patient was counted only once, thereby reducing the risk of duplicate observations.

4. **Available-case analysis:** Because laboratory and foot-assessment variables were not uniformly available for every participant, analyses were performed using variable-specific available-case denominators rather than excluding the entire dataset.
5. **Exploration of complementary risk dimensions:** The study specifically examined whether neurological sensory impairment was associated with biomechanical loading, helping to clarify whether VPT and plantar-pressure assessment provide overlapping or complementary information in diabetic-foot risk evaluation.

Limitations of the Study

1. **Retrospective cross-sectional design:** The study was based on existing clinical records and therefore cannot establish temporal or causal relationships between peripheral neuropathy, plantar-pressure abnormalities, and glycaemic control.
2. **Small sample size:** The final study population consisted of only 71 patients, with smaller numbers available for individual investigations and correlation analyses, particularly HbA1c.
3. **Incomplete laboratory data:** FBS, PPBS, and HbA1c were not available for all participants. The HbA1c correlation analysis included only 15 patients, substantially limiting statistical power.
4. **Incomplete foot-assessment data:** Although VPT and plantar-pressure assessments were available for most participants, not every patient had complete bilateral or regional measurements.
5. **Categorical plantar-pressure data:** Plantar-pressure findings were available as device-reported categories rather than continuous quantitative pressure measurements. This may have reduced the ability to detect subtle relationships between neuropathy and plantar loading.
6. **Potential selection bias:** As the study included patients who had undergone diabetic-foot assessment in a tertiary-care setting, the study population may not represent the broader community population with T2DM.
7. **Potential confounding factors:** Factors such as duration of diabetes, body mass index, foot deformity, footwear, gait characteristics, vascular status, joint mobility, treatment history,

and previous ulceration were not consistently available or incorporated into adjusted analyses.

8. **Single-centre study:** The findings are derived from one tertiary-care hospital and therefore may have limited generalizability to other clinical settings and populations.
9. **Limited neuropathy assessment:** VPT provides an objective assessment of vibration perception but does not capture every component of diabetic peripheral neuropathy. Comprehensive neurological assessment using additional modalities could provide a more complete characterization of neuropathy.

Future Directions

Future studies should use larger, prospective, multicentre cohorts with standardized and complete assessment of diabetic peripheral neuropathy and plantar loading. Continuous quantitative plantar-pressure measurements, including peak pressure and pressure-time integral, should be incorporated alongside VPT and other validated neurological assessments. Longitudinal evaluation of HbA1c and other measures of cumulative glycaemic exposure may help clarify the relationship between chronic glycaemic control and neuropathy progression. Future research should also account for potential confounders such as diabetes duration, body mass index, foot deformity, vascular status, gait characteristics, footwear, and previous diabetic-foot ulceration. Long-term follow-up studies examining whether combined VPT and plantar-pressure abnormalities predict incident callus formation, ulceration, or other diabetic-foot complications would further establish their clinical value for risk stratification and preventive care.

CONCLUSION

The present study demonstrates a high burden of VPT-defined peripheral neuropathy, with severe neuropathy affecting more than half of evaluable patients with T2DM. Advancing age was significantly associated with higher VPT, while strong bilateral correlation indicated largely symmetrical sensory dysfunction. Elevated plantar loading was common, particularly in the forefoot and heel; however, neuropathy severity was not significantly associated with regional plantar-pressure loading. FBS, PPBS, and HbA1c also showed no significant correlation with VPT in the available subset. These findings indicate that VPT and plantar-pressure assessment evaluate distinct but complementary aspects of diabetic-foot risk, supporting their combined use in comprehensive foot assessment. Larger prospective studies with complete longitudinal glycaemic data and quantitative plantar-pressure measurements are warranted.

Declarations

Ethics Approval and Consent to Participate

The study was retrospective and record-based in nature and involved analysis of previously documented clinical data without any additional intervention or diagnostic procedure. Ethical approval was obtained from the Institutional Ethics Committee of NRI General and Superspeciality Hospital, Mangalagiri, Andhra Pradesh, where applicable. The study was conducted in accordance with the principles of the Declaration of Helsinki. The requirement for individual informed consent was waived where permitted by the Institutional Ethics Committee because of the retrospective nature of the study.

Consent for Publication

Not applicable. No personally identifiable information or individual patient images are included in this manuscript.

Availability of Data and Materials

The datasets generated and/or analyzed during the current study are not publicly available because they contain clinical information but may be available from the corresponding author on reasonable request, subject to institutional and ethical restrictions.

Competing Interests

The authors declare that they have no competing interests.

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Authors' Contributions

Dr. Siva Kalyani Jyotula: Conceptualization, study design, data interpretation, manuscript preparation, critical revision, and final approval of the manuscript.

Dr. Kommi Swetha: Data collection, data analysis, literature review, manuscript preparation, critical revision, and final approval of the manuscript.

Both authors agree to be accountable for all aspects of the work and have approved the final version of the manuscript.

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AI Use Disclosure

The authors declare that no generative artificial intelligence tools were used to generate or substantially modify the scientific content of this manuscript.

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