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ORIGINAL ARTICLE

Assessment of Foot Posture in Patients with Diabetes Mellitus Using the Foot Posture Index

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ABSTRACT

Background: Diabetes mellitus is a chronic metabolic disorder associated with several complications, among which diabetic peripheral neuropathy is one of the most common. Peripheral neuropathy contributes to structural alterations of the foot, increasing the risk of deformity, ulceration, and lower-limb amputation. Early identification of these postural changes is essential for timely intervention. The Foot Posture Index (FPI-6) is a simple and reliable clinical tool used to evaluate static foot posture. **Aim:** To assess and compare foot posture in patients with diabetes mellitus with and without peripheral neuropathy using the Foot Posture Index. **Methodology:** A cross-sectional comparative study was conducted among 50 patients diagnosed with type 2 Diabetes Mellitus. Participants were selected using convenience sampling and divided into two groups based on the Neuropathy Total Symptom Score -6 (NTSS-6) : diabetic patients with peripheral neuropathy (n=25) and diabetic patients without peripheral neuropathy (n=25). Foot posture was assessed using the Foot Posture Index (FPI-6). Data were analyzed using SPSS version 26.0. Independent t- tests were used for continuous variables, and Chi-square tests for categorical variables, with statistical significance set at $p < 0.05$. **Results:** Among the 50 participants (25 with DPN, 25 without DPN), the majority (52%) belonged to the 41–50 years age group. The mean FPI-6 score for the DPN group was 8.2 ± 3.4 , compared to 2.1 ± 2.8 for the non-DPN group ($p < 0.001$). Patients with diabetic peripheral neuropathy demonstrated greater postural deviations, with highly supinated foot posture being the most common finding (40%). Participants without neuropathy predominantly demonstrated normal foot posture (48%). The difference in FPI-6 scores between groups was statistically significant ($p < 0.001$, 95% CI : 4.8-7.4). **Conclusion:** Foot posture assessment using the Foot Posture Index revealed significant postural alterations among diabetic patients with peripheral neuropathy compared to diabetic patients without peripheral neuropathy. The findings support the incorporation of foot posture assessment as an important component of diabetic foot screening protocols.

KEYWORDS

Diabetes Mellitus, Diabetic Peripheral Neuropathy, Foot Posture Index, Foot Posture, Diabetes, FPI-6, Clinical Assessment

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INTRODUCTION

Diabetes mellitus is a prevalent metabolic disorder affecting approximately 537 million adults worldwide, with India being home to an estimated 77 million individuals with diabetes (1). This chronic condition is characterized by hyperglycemia resulting from defects in the insulin secretion, insulin action, or both (2). Type 2 diabetes mellitus, which accounts for approximately 90-95% of all diabetes cases, typically develops in adulthood and is characterized by insulin resistance with varying degrees of pancreatic beta-cell dysfunction (3). Chronic hyperglycemia in diabetes leads to microvascular and macrovascular complications, including retinopathy, nephropathy, and cardiovascular disease, all of which significantly increase morbidity and mortality (4). Among these complications, diabetic peripheral neuropathy (DPN) is one of the most frequently observed and contributes substantially to the development of foot ulcers and the lower limb amputations (5). Approximately one-third to one-half of individuals with diabetes develop peripheral neuropathy, making it a major public health concern (6). DPN affects both sensory and motor nerves. Sensory neuropathy results in loss of protective sensation, while motor neuropathy causes denervation and subsequent atrophy of intrinsic foot muscles (7). This muscular imbalance disrupts normal foot biomechanics, leading to structural alterations including claw toe deformities, pes-cavus (high-arched foot), and abnormal weight distribution (8). These changes, combined with sensory loss, create a “perfect storm” for painless tissue breakdown and ulceration (9).

The Foot Posture Index (FPI-6) was developed as a quick, reliable clinical tool for assessing static foot posture in multiple segments without requiring complex measurement techniques (10). Its six validated criterion-based observations evaluate both rearfoot and forefoot position, making it particularly suitable for clinical settings where time and resources are limited. The FPI has demonstrated good internal construct validity and has been successfully applied in various studies of biomechanical risk factors for neuropathic ulceration in diabetes (11).

NEED OF THE STUDY

A critical gap exists in the current diabetic foot screening protocols. While sensory neuropathy is routinely assessed, the structural consequences of motor neuropathy - including intrinsic muscle atrophy and subsequent foot deformity - remain undetected until complications develop (12). Establishing FPI-6 as a reliable screening tool can empower clinicians to make timely referrals for orthotic management, effectively preventing costly and devastating complications (13).

MATERIALS AND METHODOLOGY

To assess and compare foot posture in patients with diabetes mellitus with and without peripheral neuropathy using the Foot Posture Index.

Objectives

1. To assess foot posture in diabetic patients with peripheral neuropathy using the Foot Posture Index.
2. To assess foot posture in diabetic patients without peripheral neuropathy using the Foot Posture Index.

3. To compare foot posture between diabetic patients with and without peripheral neuropathy using the Foot Posture Index.

Methodology Study Design

A cross - sectional comparative study was conducted.

Sampling Technique

Convenient sampling was employed .

Sample size

A total 50 participants were enrolled in the study. The sample size was calculated based on the previous studies[14], with $\alpha=0.05$ and power=80% , estimating an effect size of 0.8 between groups. A minimum of 42 participants was required ; we recruited 50 (25 paper group) to account for potential dropouts.

Participant allocation

Participants were divided into two groups based on their neuropathy Total Symptom Score -6 (NTSS-6):

- Group A: Diabetes mellitus with peripheral neuropathy (n=25)
- Group B: Diabetes mellitus without peripheral neuropathy (n=25)

Study Area

The study was conducted at various clinicals of diabetologist surrounding pune area

Study Duration

The study was conducted over a period of 6 months (January 2024 to June 2024).

Ethical considerations

Ethical approval was obtained from the Institutional Ethics Committee of Late Shree Fakirbhai Pansare Education Foundation's College of Physiotherapy . The study was conducted in accordance with the declaration of Helsinki. Written informed consent was obtained from all participants prior to data collections.

Outcome Measure

Foot Posture Index (FPI-6) was used as the primary outcome measure .

Inclusion Criteria

1. AGE GROUP - 35-55 years of age.
2. Patients diagnosed with type 2 diabetes mellitus.
3. Patients diagnosed with or without neuropathy using Neuropathy Total Symptom Score-6 scale.
4. Patients with a minimum of five years since diagnosis.

Exclusion Criteria

1. Diabetic complications such as foot ulcers.
2. Recent lower limb or ankle fracture.
3. Charcot foot.
4. Gestational diabetes.
5. Musculoskeletal complications like recent ankle sprain (1- 2yrs).

PROCEDURE

1. Ethical approval was obtained from the Institutional Ethics Committee.
2. Individuals were approached, and those fulfilling the inclusion criteria were selected.
3. Written informed consent was obtained from all participants.
4. After filling the consent form, the participants' demographic data was collected.
5. The participants were divided into two groups based on their NTSS-6 scale, one with diabetic peripheral neuropathy and one without.
6. Both groups were assessed for foot posture using foot posture index scale (FPI).
7. On the basis of instructions in the scale of Foot Posture Index and Neuropathy Total Symptom Score -6 the scores were noted.

Scores of both groups were compared and data were analyzed.

Assessor reliability

All FPI-6 assessments were performed by a single trained physiotherapist who had undergone standardized training in FPI-6 administration. Intrarater reliability was established by reassessing 10 randomly selected participants after 48 hours (ICC = 0.92, 95% CI: 0.85-0.96).

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA).

RESULTS AND OBSERVATION:

Statistical tests used:

1. Descriptive statistics (mean, standard deviation, frequency, percentage) were used to summarize demographic and clinical characteristics.
2. The Shapiro-Wilk test was used to assess the normality of data distribution.
3. The independent t-test was used for normally distributed continuous variables.
4. The Mann-Whitney U test was used for non-normally distributed variables.
5. The Chi-square test was used for categorical variables.
6. Statistical significance was set at $p < 0.05$.

A total of 50 participants diagnosed with Type 2 Diabetes Mellitus were included in the study. Twenty-five participants had diabetic peripheral neuropathy (Group A), while twenty-five participants did not have peripheral neuropathy (Group B).

Demographic Characteristics

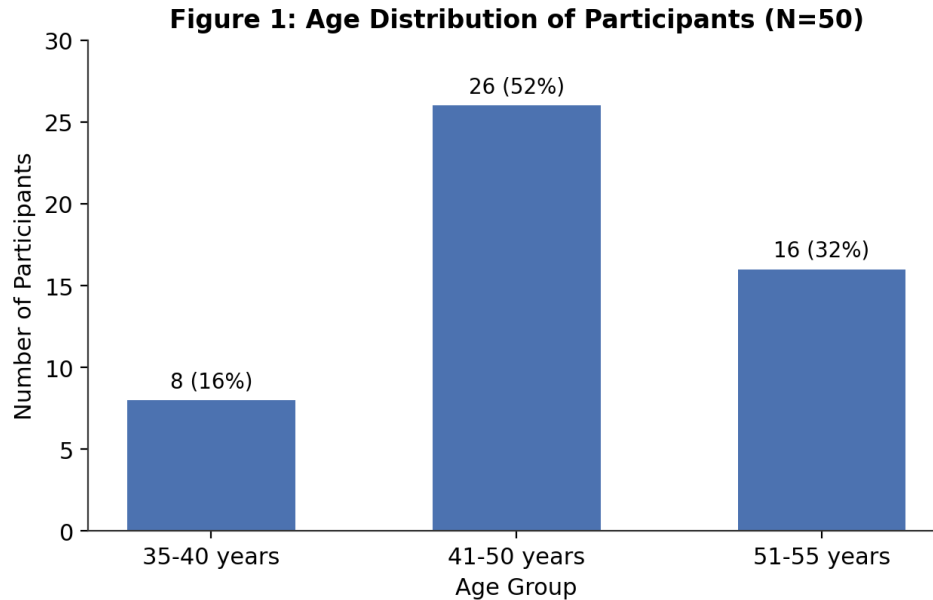
Characteristic	DPN Group(n=25)	Non-DPN Group (n=25)	p-value
Age(years)	47.2± 6.8	45.8 ± 7.2	0.481*
Gender(M/F)	14/11	16/9	0.559+
Duration of DM(years)	8.4 ± 3.2	7.9 ± 3.1	0.572*
BMI(kg/m2)	26.4 ± 4.1	25.8 ± 3.8	0.590*

*Independent t-test ; +Chi-square test

Values are presented as Mean ±SD or n
p<0.05 considered statistically significant

The majority of participants (52%)belonged to the 41–50 years age group. There were no significant differences in demographic characteristics between groups (p>0.05 for all comparisons), indicating comparable baseline characteristics .

Figure 1 : Age Distribution of Participants



Neuropathy Severity Scores

Table 2 : Neuropathy Total Symptom Score - 6 (NTSS-6) Distribution

NTSS-6 Category	DPN Group (n=25)	Non-DPN (n=25)	P-value
NTSS-6 Score (Mean * SD)	11.4±3.6	2.8 ± 1.9	<0.001*
Mild (6-10)	12(48%)	-	-
Moderate(11-15)	8(32%)	-	-
Severe(>15)	5(20%)	-	-

*Independent t-test $p < 0.05$ considered statistically significant

FPI-6 Scores

Table 3 : Comparison of FPI-6 Scores between Groups

Parameter	DPN Group (n=25)	Non - DPN group (n=25)	p-value	95% CI
FPI-6 Total Score	8.2 ± 3.4	2.1 ± 2.8	<0.001*	4.8-7.4
FPI Category			0.002+	-
-Highly pronated	3(12%)	1(4%)	-	-
-Pronated	5(20%)	5(20%)	-	-
-Normal	7(28%)	12 (48%)	-	-
-supinated	0(0%)	5(20%)	-	-
-Highly Supinated	10 (40%)	2(8%)	-	-

* Independent t-test ;+ Chi-square test

Values are presented as Mean ± SD or n(%)

$p < 0.005$ considered statistically significant

Figure 2 : Comparison of FPI-6 Categories Between Groups

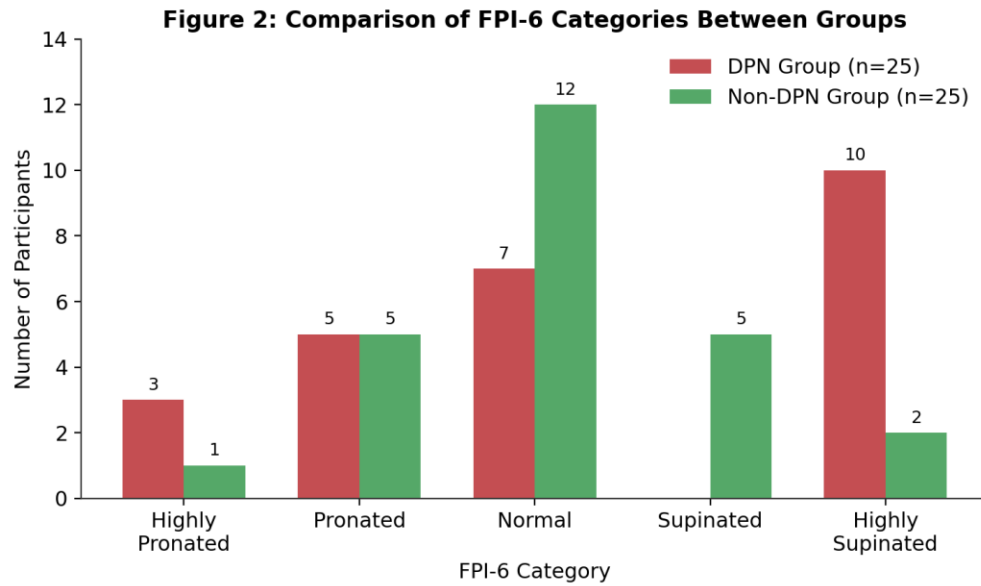
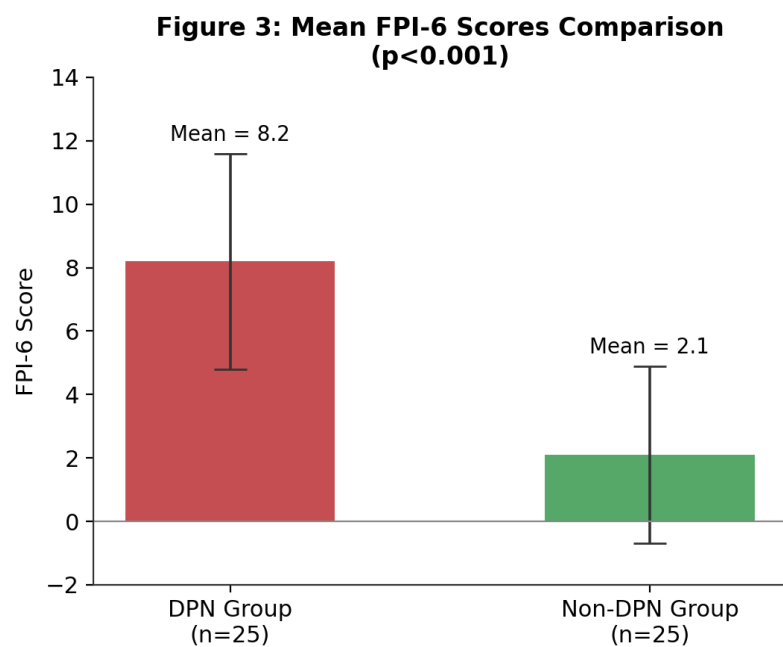


Figure 3 : Mean FPI -6 scores Comparison



SUMMARY OF FINDINGS

Among participants with diabetic peripheral neuropathy:

- Highly supinated foot posture was the most commonly observed finding(40%)
- Normal Foot Posture (28%),pronated (20%),and highly pronated (12%) were observed

Among participants without peripheral neuropathy:

- Normal foot posture was the predominant finding (48%)
 - Supinated (20%), pronated (20%), and highly pronated (4%) were also observed
- Comparison between the two groups demonstrated greater postural deviations in participants with diabetic peripheral neuropathy (mean FPI-6 : 8.2 ± 3.4 vs 2.1 ± 2.8 ; $p, 0.001$).

Discussion

The present study successfully utilized the Foot Posture Index (FPI-6) to assess and compare foot posture in diabetic patients with and without peripheral neuropathy. The findings robustly demonstrate a critical link between Diabetic Peripheral Neuropathy (DPN) and significant postural deviations.

Comparison with Previous Studies

The most salient finding was the stark contrast between the two groups. While nearly half (47%) of the patients without neuropathy maintained a neutral foot posture, this proportion was markedly lower (26%) in the neuropathic group. This divergence was characterized by a pronounced shift towards severe deformity in the DPN group, with a notable 40% presenting with a highly supinated foot (Pes Cavus).

Our findings are consistent with previous research by Bus et al.[7], who used MRI to demonstrate intrinsic muscle atrophy in the diabetic neuropathic foot. Our study builds upon this by translating that pathological finding into a clinically observable and quantifiable outcome using the FPI-6. The atrophy documented in their study manifests predictably as a highly supinated foot posture, which can be efficiently identified in a routine clinical setting without the need for advanced imaging.

Furthermore, our findings support the work of Aquino et al.[11], who validated the reliability of the FPI-6 in clinical settings. The highly intrarater reliability established in our study (ICC=0.92) aligns with their findings and confirms the clinical utility of this tool.

Clinical Significance

The structural alterations observed in this study have direct clinical implications. A rigid, deformed foot compromises shock absorption and pressure distribution, increasing the risk of high-pressure areas that can lead to ulceration[8]. In the case of a supinated foot, elevated pressure on the lateral border and the heel, combined with the sensory loss that defines DPN, creates a perfect storm for painless, unnoticed tissue breakdown. Our data therefore confirms that a foot with neuropathy is not merely an “insensate foot,” but more critically, a “deformed foot”, which carries a vastly higher biomechanical risk[7].

Clinical recommendations :

The practical implication of our findings is that annual diabetic foot screening should incorporate FPI- 6 assessment alongside sensory testing. For patients identified with abnormal foot posture , we recommend :

1. Immediate referral for podiatric assessment
2. Prescription of custom - molded orthotics to redistribute plantar pressure
3. Patient education on daily foot inspection , particularly in areas of high pressure
4. Regular follow -up (every 3-6 months) for patients with FPI scores indicating significant deviation

Strengths of the Study

1. Use of a validated , reliable clinical tool (FPI-6)
2. Clear comparison between well- defined groups
3. Established intrarater reliability
4. Clinically applicable findings

Limitations

The findings are limited by the cross-sectional study design, which assesses foot posture at a single point in time and cannot establish a causal relationship between the duration of neuropathy and postural changes

This study could not determine whether the observed foot alterations were pre-existing postural issues or a direct consequence of the diabetes mellitus diagnosis

Conclusion

The study concludes that assessment of foot posture using the Foot Posture Index demonstrates significant postural alterations in diabetic patients with peripheral neuropathy compared to diabetic patients without peripheral neuropathy. Diabetic patients with peripheral neuropathy demonstrated significantly higher FPI-6 scores, indicating greater postural deviations, with highly supinated foot posture being the most common finding. These findings support the incorporation of foot posture assessment as a valuable clinical tool for identifying patients at increased risk of foot deformity.

Future Scope

1. Subsequent research can correlate FPI findings with objective biomechanical and neurological data, such as gait analysis and nerve conduction studies. This will help establish FPI not just as a screening tool, but as a predictor for specific pathological pathways.
2. Impact of implementing routine FPI screening in primary diabetes care to prevent costly ulcer treatments and amputations.

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