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# Assessment of two-point discriminatory ability in patients with type-II diabetes mellitus

**Arya M. Kulkarni[1], Khushbu Patel[2], Prachi Khokhariya[3], Niharika Chaudhary[4], Vaishali H. Pargi[5], Sumit R. Chaudhary[6], Akanksha Patel[7], Chirag Rathwa[8], Sachin Singh[9], Aniket Karmata[10], Dhruv A. Donga[11], Margi Detroja[12], Renish Badi[13], Jahnavi Mahyavanshi[14], Shreyansh N. Raval[15*]**

GMERS Medical College, Vadnagar, Gujarat, India.

[*]**Correspondence**
Shreyansh N. Raval
shreyanshraval21@gmail.com

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**Background:** Diabetes is a complex, chronic condition that is a severe public health concern of the modern world. A wide range of co-morbidities and microvascular complications are associated with diabetes and one such major microvascular condition of diabetes that, if left untreated, leads to long-term disability among patients is Diabetic neuropathy. The primary goal of this study is to assess the tactile discriminatory function in patients with Type-2 Diabetes Mellitus and compare it with patients who do not have type-2 diabetes mellitus.

**Methods:** This case-control study, conducted at a tertiary rural healthcare centre, used a cross-sectional design. 53 individuals with a verified diagnosis of type-2 diabetes were included in the case group based on non-randomized sampling. These were contrasted with patients in the control group who did not have diabetes who were age and sex matched. The participants' tactile discrimination ability was measured using a millimetre-marked compass aesthesiometer. The tips of the index fingers on both the right and left hands, the palmar surfaces of the palms on the hands, the ventral surface of the forearms on the right and left, the plantar surfaces of the big toes on both the right and left foot, and the plantar surfaces of the soles on both the right and left foot were used as the testing sites. Data showing the two-point discrimination thresholds of the case and control groups were compared and tabulated.

**Results:** The unpaired t-test was done using all the values of two-point discriminatory thresholds in the diabetic and non-diabetic groups at 10 different sites at the upper and lower limbs as mentioned previously. The t values for all the test sites were significant with p values $< 0.05$. This indicates that the tactile discriminatory thresholds at all the testing sites, differ significantly in diabetic and non-diabetic groups. The current study also aimed to demonstrate a statistically significant association between the duration of diabetes and the reduced sensory abilities of diabetic patients. The Pearson's correlation Test was used to achieve this, but the results were unsatisfactory and somewhat at odds with the findings of several earlier investigations, which had discovered a strong positive link with the duration of diabetes with that of increased values of tactile discriminatory thresholds of the diabetic group. Since the correlation coefficients were not significant, it was not possible to determine a meaningful relationship between the duration of diabetes and the diabetic case group's reduced sensory abilities.

**Conclusion:** Our study highlights how the two-point discrimination test can aid in the early detection of tactile sensation loss in diabetic patients. The two-point discriminatory thresholds between the diabetic and non-diabetic groups differ significantly, according to the results of the study. Additionally, the data indicates higher threshold values, which point to a marked decline in tactile function in the diabetic group.

***Keywords:*** *diabetes, tactile discrimination, sensory, assessment, control*

## Introduction

Diabetes Mellitus is a metabolic disease marked by hyperglycaemia brought on by an insulin resistance or shortage, or by any pathological condition that results in the loss or dysfunction of the β cells of the pancreatic islets. Along with other microvascular complications and cardiovascular anomalies, it is linked to a broad spectrum of co-morbidities, including ketoacidosis, nephropathy, retinopathy, and neuropathy. The International Diabetic Federation projects that by 2045, 1 in 8 adults, or approximately 783 million, will have diabetes. Type-2 Diabetes is recognised as a major public health concern, with a global burden of 537 million cases (2021) in the age group of 20-79 years living with Type-2 DM. (IDF Diabetes Atlas, n.d.)

Diabetes can lead to significant complications, one of which is diabetic neuropathy. It is one of the most frequent causes of non-invasive amputations, foot infections, and ulcerations. As a result, patients with diabetes may experience significant psychological and financial strain in addition to long-term disability. The most prevalent kind of diabetic neuropathy that affects people with Type 1 and Type 2 diabetes is called distal symmetric polyneuropathy. In addition to distally impaired vibration, joint position, touch-pressure, and aberrant ankle reflexes, large-fibre involvement causes tingling paraesthesia and a numbness in the feet, these sensations are not necessarily accompanied by pain (Bansal et al., 2006; Feldman et al., 2019; Edwards et al., 2008). On the other hand, scorching, prickling, and stabbing sensations are most often the consequence of small-fibre involvement, which leads to chronic neuropathic pain (Mackenzie and DeLisa, 1981 and Tesfaye & Kempler, 2005).

Diabetes duration, degree of glycaemic regulation, age-related neuronal attrition, and other factors like tobacco smoking, elevated blood pressure, weight gain, dyslipidaemia, etc. are thought to play a complex role in the exact pathogenesis of diabetic neuropathy, which is thought to be multifactorial (Tesfaye et al., 2005; Wiggin et al., 2009; Pearsall & Russell, 2000; Witte et al., 2004 and Stella et al., 2000). Numerous biochemical pathways are triggered in response to different stresses on the nerve conduction pathways and other risk factors. These pathways result in structural alterations like segmental demyelination, Wallerian degeneration, and microangiopathy, as well as the induction of neuronal apoptosis in the dorsal root ganglia (Saleh et al., 2013; O'Brien et al., 2014 and Vincent et al., 2005). Other additional mechanisms include the increased synthesis of Advanced Glycation End Products (AGEs) that further damage the nerve terminals and the increased production of reactive oxidant species from mitochondria caused by hyperglycaemia.

Currently, peripheral neuropathy and progressive tactile discriminatory function loss is diagnosed based on clinical signs and symptoms in diabetic patients after other causes of neuropathy have been ruled out (Bansal et al., 2006). Nerve conduction studies must be carried out to confirm the diagnosis, but most medical facilities do not have access to this method. Therefore, the goal of this study is to evaluate the tactile discriminatory function in patients with Type-2 Diabetes Mellitus using a compass aesthesiometer to carry out a two-point discrimination test, and to use it as an initial screening tool for diagnosing diabetic neuropathy.

**Aims & Objectives:**

Aim: To assess tactile discrimination in Type-2 Diabetes Mellitus patients in a tertiary rural healthcare centre

Objectives:

1. To compare the tactile discriminatory thresholds at various sites on upper limb and lower limb, of patients with Type- II Diabetes Mellitus with that of normal (control group) individuals.
2. To find out the extent of tactile function loss in Type- II Diabetes Mellitus patients

To assess the tactile discriminatory ability based on the test site, age, sex and other comparable parameters.

## Materials and Methods

All subjects provided their informed consent. This is a case-control single time point observational study, which took place in 2023 at Gmers Medical College, Gujarat, India. Based on a non-random sampling method, 53 subjects were taken for the study. 30 of these participants were males and 23 were females.

Inclusion criteria:

1. Patients with Type II Diabetes Mellitus
2. Patients in the age group of 30-85 years
3. Duration of Diabetes Mellitus: > 6 months

4. No prior history or diagnosis of diabetic neuropathy or any other neuropathy or radiculopathy

Exclusion criteria:

1. Patients previously diagnosed with upper limb or lower limb diabetic neuropathy
2. Any other neuropathy/radiculopathy
3. Diagnosed with Neuro-musculoskeletal disorders such as; Parkinson's disease, Huntington's disease, polio, Multiple sclerosis, traumatic nerve injury, carpal tunnel syndrome, etc.
4. Diagnosed with diabetic foot or cellulitis

The 45 individuals in the control group were matched according to age, sex, and whether or not they had been diagnosed with diabetes or any other co-morbidities—that is, if they appeared to be healthy. 31 of the non-diabetic individuals were males and 14 were females.

**Sensory evaluations**

The tactile discrimination ability of the subjects in the control and case groups was measured using a millimetre-marked compass aesthesiometer device. The test was conducted in a quiet environment with the subject's vision occluded. On the examination table, the subject's hands were completely supported. The compass aesthesiometer's two points were simultaneously placed on the skin of the test sites, and the distance between them was gradually increased in a longitudinal orientation. The minimum distance at which the subject perceives 2 separate points of stimulation was recorded. The participants expressed vocally whether and where they thought the points of the callipers were. This point is known as the ***two-point discrimination threshold***. ***Tactile acuity*** is measured by the two-point discrimination threshold. The tips of the index fingers on both the right and left hands, the palmar surfaces of the palms on the hands, the ventral surface of the forearms on the right and left, the plantar surfaces of the big toes on both the right and left foot, and the plantar surfaces of the soles on both the right and left foot are the locations for the tests. The control group underwent the identical process, and the observations (measured in millimetres) were noted. A Google form was used to build the digital pro-forma, and it was filled out with the subjects' demographic details as well as their individual observations.

## Results

**Table 1. Two-point discriminatory threshold values of Diabetic Group**

| Sr. No. | Site of examination | Minimum Threshold (mm) | Maximum Threshold (mm) | Mean | Standard deviation |
|---|---|---|---|---|---|
| 1. | Right Index finger | 1 | 8 | 3.42 | 1.646 |
| 2. | Left Index finger | 1 | 9 | 3.64 | 1.902 |
| 3. | Right Palm | 2 | 15 | 6.04 | 2.862 |
| 4. | Left Palm | 2 | 15 | 6.47 | 3.490 |
| 5. | Right Forearm | 3 | 18 | 9.11 | 4.681 |
| 6. | Left Forearm | 2 | 17 | 8.04 | 4.146 |
| 7. | Right Greater Toe | 0 | 7 | 3.91 | 2.012 |
| 8. | Left Greater Toe | 0 | 8 | 4.34 | 2.166 |
| 9. | Right Sole of foot | 0 | 19 | 8.15 | 5.3 |
| 10. | Left Sole of foot | 0 | 20 | 9.45 | 5.380 |

**Table 2. Two-point discriminatory threshold values of Non- Diabetic (Control) Group**

| Sr. No. | Site of examination | Minimum Threshold (mm) | Maximum Threshold (mm) | Mean | Standard deviation |
|---|---|---|---|---|---|
| 1. | Right Index finger | 1 | 5 | 2.02 | 0.78 |
| 2. | Left Index Finger | 1 | 4 | 2.04 | 0.928 |
| 3. | Right Palm | 1 | 7 | 4 | 1.382 |
| 4. | Left Palm | 2 | 8 | 4.55 | 1.672 |
| 5. | Right Forearm | 3 | 13 | 6.06 | 2.815 |

| | | | | | |
|---|---|---|---|---|---|
| 6. | Left Forearm | 3 | 15 | 6.31 | 3.436 |
| 7. | Right Greater Toe | 1 | 4 | 3.13 | 0.625 |
| 8. | Left Greater Toe | 1 | 5 | 3.31 | 0.874 |
| 9. | Right Sole of foot | 4 | 13 | 7.11 | 2.207 |
| 10. | Left Sole of foot | 3 | 15 | 7.467 | 2.272 |

**Table 3. Comparison between Two-point discriminatory threshold values in diabetic and non-diabetic groups**

| Sr. No. | Sites | T value | P value |
|---|---|---|---|
| 1. | Right Index finger | 5.196 | <0.0001 |
| 2. | Left Index Finger | 5.154 | <0.0001 |
| 3. | Right Palm | 4.361 | <0.0001 |
| 4. | Left Palm | 3.37 | <0.0001 |
| 5. | Right Forearm | 3.82 | <0.0001 |
| 6. | Left Forearm | 2.22 | <0.0001 |
| 7. | Right Greater Toe | 2.47 | <0.0001 |
| 8. | Left Greater Toe | 2.98 | <0.0001 |
| 9. | Right Sole of foot | 1.23 | <0.0001 |
| 10. | Left Sole of foot | 2.31 | <0.0001 |

As seen in the table above, the unpaired t-test was done using all the values of two-point discriminatory thresholds in the diabetic and non-diabetic groups at 10 different sites at the upper and lower limbs as mentioned previously. The t values for all the test sites were significant with p values < 0.05. This indicates that the tactile discriminatory thresholds at all the testing sites, differ significantly in diabetic and non-diabetic groups.
The values of Pearson correlation coefficient were not significant for any of the test sites, therefore no significant correlation could be established between reduced tactile sesation in the diabetic case group and duration of diabetes.

**Table 4. Pearson correlation coefficient values for 4 testing sites to determine the relation between tactile sensations with the duration of diabetes**

| Sr. No. | Sites | R value | P value |
|---|---|---|---|
| 1. | Right Index Finger | 0.076 | 0.585 |
| 2. | Left Index Finger | 0.186 | 0.181 |
| 3. | Right Greater Toe | -0.119 | 0.396 |
| 4. | Left Greater Toe | 0.145 | 0.299 |

## Discussion

This study aims to investigate the two-point discriminatory ability of patients with type-2 Diabetes Mellitus and the possible impact of the duration of diabetes on the patients' upper and lower limb sensory abilities. The majority of prior research (Periyasamy et al., 2008; Boulton, 2004; Kamei et al., 2005) used a range of modalities, such as temperature, vibration, point localization, and TPD, to evaluate the loss of perception in diabetic foot. Neuropathy is more common in the lower limbs than in the upper limbs because lower limb nerves are affected more frequently than upper limb nerves. (KASTHURI and others, 2000). In this study, we attempted to evaluate sensory loss in the upper and lower limbs of patients with Type-2 DM using two-point discrimination test using a compass aesthesiometer. This study assessed and compared the values of TPD thresholds of the case group with those with age and sex matched control persons who were not diagnosed with diabetes or any other co-morbidities. According to Manivannan et al. (2008), this test is the currently advised way to assess and screen for the degree of sensory loss in diabetic patients. The two point discrimination values between those with diabetes and those without it were determined to be greatly significant in the current investigation. According to Periyasamy et al. (2008) and other investigations, the TPD values of the diabetic people were consistently greater than those of the normal population.

The tactile discriminatory thresholds of those without diabetes and those with diabetes differ significantly, according to the current study's findings. When compared to the non-diabetic group, the TPD thresholds of the diabetic group were found to be increased. Despite the patients' lack of any noticeable symptoms or impairment, the clinical assessment of their senses showed changes, which may point to an underlying neuropathy (Sarkar et al., 2011; Callaghan et al., 2012). The current study also aimed to establish a statistically significant positive correlation between, the period since the

patients were diagnosed with diabetes and the reduced sensory abilities of diabetic patients. The Pearson's Correlation Test was used to demonstrate this, however the results were unsatisfactory and somewhat conflicting with the findings of several earlier research, which revealed a strong positive link with the length of diabetes and the high TPD thresholds of diabetic patients (Sarkar et al., 2011). The correlation coefficient values were not significant, hence hindering the establishment of a positive correlation between TPD thresholds of diabetic patients with that of duration of diabetes. Electrophysiological techniques such as nerve conduction tests are the gold standard for diagnosing peripheral neuropathy(Perkins et al., 2001), hence patients who showed worsening sensations in their upper or lower limbs following screening with the two-point discrimination test may be referred for these tests in order to get a definitive diagnosis of peripheral neuropathy (Sarkar et al., 2011).

## Conclusion

Our study highlights how the two-point discrimination test can aid in the early detection of tactile sensation loss in diabetic patients. The information shows that the two-point discriminating thresholds for the groups with and without diabetes differ significantly. The data also shows increased threshold values, indicating significant deterioration of tactile function in the diabetic group. The degree of tactile sensory loss and its progression to peripheral neuropathy is often neglected by patients with diabetes and this eventually becomes debilitating for the patients, unless they receive an early diagnosis and appropriate management for this condition. Patients who have had diabetes for five years or more should have their hands and feet tested for tactile sensations, and their physician should provide them with the necessary information about the impending risk of developing peripheral neuropathy and appropriate advice on how to take care of their hands and feet. There is no considerable recovery after neuropathy is established. Therefore, the only way to avoid a serious loss of tactile function and disability is to diagnose and treat this condition as soon as possible.

## Author contributions

All authors have contributed equally and substantially.

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## Conflict of interest

The author declares no conflict of interest. The manuscript has not been submitted for publication in other journal.

## Ethics approval

Not applicable

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