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Assessment of Upper Limb Sensory Deficit in People with Type 2 Diabetes Mellitus – A Descriptive Study

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***Abstract*: Background and objective of study: The term diabetes mellitus describes a metabolic disorder of multiple etiology characterized by chronic hyperglycemia with disturbance of carbohydrate, fat and protein metabolism resulting from deficit in insulin secretion, insulin action or both. Neurologic complications occur in diabetes mellitus where small fiber damage affects sensation of temperature, light touch, pinprick, and pain. Large fiber damage diminishes vibratory sensation, position sense, muscle strength, sharp-dull discrimination, and two-point discrimination. Numerous prior studies had shown that abnormal sensory functioning of the hand from several types of diseases may lead to poor motor performance, but few reported the outcomes related to diabetic hands. Therefore, it was necessary to know the extent and the severity of sensory involvement in type 2 diabetes mellitus in order to design the rehabilitation protocol of upper extremity accordingly.**

Methods: A total of 60 subjects having history of type 2 diabetes were recruited for the study. The written informed consent and institutional ethical clearance were obtained from them. The subjects underwent thorough sensory evaluation of upper extremity, which included assessment for pain, touch, tactile localization, temperature, two-point discrimination, stereognosis, vibration and graphesthesia.

Results: The data was described using descriptive statistics. Pain was the unaffected sensory component for all the subjects. 60% of subjects had impaired two-point discrimination which was the most affected component. Touch, temperature, tactile localisation, graphesthesia, vibration and stereognosis were also affected in 35%, 44%, 27%, 45%, 32% and 39% subjects respectively.

Conclusion: The current study concluded that two-point discrimination was most affected component. Pain was the unaffected sensory component. The most to least affected components were graphesthesia, temperature, stereognosis, touch, vibration and tactile localisation respectively. The conclusion indicates that there are some degree of sensory involvement in upper extremity in type 2 diabetic subjects and equal importance should be given to upper extremity while assessing the neuropathy along with the lower extremity.

***Keywords*: Pain, Sensory Evaluation, Tpd, Type 2 Diabetes, Upper Exterimity.**

1. Introduction

The term diabetes mellitus describes a metabolic disorder of multiple etiology characterized by chronic hyperglycemia with disturbance of carbohydrate, fat and protein metabolism resulting from deficit in insulin secretion, insulin action or both [1]. Diabetic patients often develop different chronic complications which decrease their quality of life [2]. Diabetes mellitus(DM)-related complications include neuropathy, retinopathy, nephropathy, cardiovascular and musculoskeletal disease [3].

Diabetes is one of the seventh most devastating non communicable disease affecting half of the population in the world. The International Diabetes Federation (IDF) and Diabetes Atlas reports that there are 415 million people diagnosed with diabetes. This population represents 8.8% of adults aged between 20–79 years in India [4]. It is further predicted that the number of adults with diabetes will increase to more than 640 million by 2040 [4]

Diabetes is a silent disorder leading to disabling and fatal complications that are related with increased costs. The long-term complications of diabetes affect almost every system in the body, especially the eyes, kidneys, heart, feet and nerves. The micro- and macrovascular complications include anatomic, structural and functional changes, which leads to multiple organ dysfunction. Causative factors include persistent hyperglycemia, microvascular insufficiency, oxidative and nitrosative stress, defective neurotrophism, and autoimmune mediated nerve destruction [5].

The true prevalence of diabetic neuropathy (DN) is not known and reports vary from 10% to 90% in diabetic patients, depending on the criteria and methods used to define neuropathy [6]-[9]. In a study it was found that among diabetic population 50% had neuropathy after a simple clinical test such as the ankle jerk or vibration perception test, almost 90% tested positive to sophisticated evaluations of autonomic function or peripheral sensation [10].

Diabetic neuropathy is generally subdivided into focal/multifocal neuropathies, including diabetic amyotrophy, symmetric polyneuropathies and diabetic sensorimotor polyneuropathy (DSPN). The proper diagnosis requires a thorough history, clinical and neurological examinations and exclusion of secondary causes [11]. Neurologic complications

occur equally in type 1 and type 2 diabetes mellitus and additionally in various forms of acquired diabetes [12]. In sensory nerve damage, the nerves with the longest axons usually are affected first, resulting in a stocking and glove distribution. Small fiber damage affects sensation of temperature, light touch, pinprick, and pain. Large fiber damage diminishes vibratory sensation, position sense, muscle strength, sharp-dull discrimination and two-point discrimination [13].

Generally, "sensibility" is defined as normal touch, diminished light touch, diminished protective sensation, and loss of protective sensation [14] Various modalities of touch sensation, such as pressure, vibration, and two point discrimination (TPD), are used to test loss of sensation or sensibility [15]- [17]. The peripheral nervous system (PNS) lies between the transducers at our muscles, joints, and skin and the central nervous system (CNS). Thus, the PNS carries information about responses to movement, pressure, patterns, and temperature. The end organs, themselves, are tuned to be optimally sensitive to specific types of energy input, [18] which is "exquisite, but not exclusive." [19] These members work in concert to produce the quality of sensibility, including active touch [20]- [24].

The problem for the examiner extends beyond measurement and documentation of sensibility to that of recognizing the stage and degree of involvement so that treatment considerations can be made with the highest probability of positive outcomes. If the injury is detected early enough, treatment to restore PNS function can be considered. That failing, in the case of irreversible nerve damage, retraining of capabilities is based on residual PNS function. No treatment can ever be superior to preventing the problem from developing in the first place. Thus, the earliest detection of reduced sensation is paramount to keep the patient from unintentional self-inflicted damage, which may occur at levels of reduced protective sensation. The measurement of residual PNS function becomes the baseline for detecting new damage, with the hope that early detection can prevent further loss of PNS function [25].

Evaluation should be of greater importance in a neuropathy which is predominantly sensory and studies have shown that conduction velocity is diminished, sensory amplitude potentials reduced and spinal somatosensory conduction slowed early in diabetic neuropathy, reflecting loss of distal myelinated sensory axons [26]- [28].

Numerous prior works have shown that abnormal sensory functioning of the hand from several types of diseases may lead to poor motor performance, but few report the outcomes related to diabetic hands [29]. Hands are critical organs with sophisticated anatomical structures, as well as precise movement functions for dealing with various daily and occupational tasks, and diabetes may result in progressive physical and functional impairments of neuropathic hands [30].

Despite evidence that type 2 diabetes has been associated with functional impairment to all four limbs, only a handful of studies have been performed to evaluate the effects of type 2 diabetes manual behaviors [29]. Over 90 % of diabetic patients diagnosed with neuropathy reportedly present with sensory symptoms, while approximately 77 % have experienced motor symptoms [31]. Despite the high incidence of both sensory and motor symptoms with diabetic neuropathy, evaluation and treatment of diabetic peripheral neuropathy have been focused solely on the lower extremity [32], [33].

While many previous works focus on the pathology and functional interference associated with diabetic feet, few explore the effects of diabetic hands [34]-[36]. There are a wide range of symptoms associated with diabetic hand syndrome, such as numbness, chronic pain, stiffness, tingling, reduced strength, abnormal sensory functioning or fatigue and these can lead to deficits in the sensorimotor control and even functional performance of the hand [37]-[39]. Therefore, it was necessary to know the extent and the severity of sensory involvement in type 2 diabetes mellitus in order to design the rehabilitation protocol according to the need of those. So the present study threw light on the extent of sensory impairment and the most affected sensory component of upper extremity in type 2 diabetic population.

A. Objectives

To assess the extent of sensory deficits of upper limb in type 2 diabetes mellitus. To find out the most affected sensory component among them.

2. Methodology

A. Source of the data

Subjects were recruited from Jnana Sanjeevini Hospital, Bangalore and Outpatient Department of R V College of Physiotherapy, Bangalore.

B. Method of collection of data

The investigator contacted the above mentioned authorities and obtained permission from the concerned authorities. Subsequently, after obtaining the permission, the investigator obtained signed informed consent from the subjects, then the investigator screened the subjects according to inclusion criteria and exclusion criteria to meet the requirements and the study was continued.

C. Study design

Descriptive study.

D. Sample and sampling techniques

- *Sample size:* Sample consisted of 60 samples calculated from prevalence studies.
- *Sample size calculation:* α = 0.05 (type- I error), d = 10% = 0.1 (anticipated error), p = 0.088 (prevalence), q = 0.912 (1-p), design effect of 2
  n =Zα/2 2 ×pq d2
  Net sampling size = n*2
  Sampling technique: Purposive sampling.

E. Materials required

- Pin bent at right angle
- Aesthesiometer
- Test tubes
- Tuning fork
- Coin
- Monofilament
- Stationery
- Thermometer

Fig. 1. Materials required

F. Inclusion criteria

Subjects with type 2 diabetes for more than ten years.
Subjects who were willing to be a part of the study and signed the informed written consent.

G. Exclusion criteria

Other neurological conditions which had similar symptoms of diabetic neuropathy.
Ulcerated hands and upper limb trauma.
Skin diseases of the upper limb.
Musculoskeletal conditions causing pain and discomfort in the upper limb.
Subjects having signs of inflammation in the upper limb.
Subjects who were on medical management for diabetic neuropathy

H. Procedure

The recruited subjects underwent a detailed standard sensory examination.39,40 pain, touch, temperature and tactile localization were assessed in 7 dermatomes (C3-T1).

I. Pain sensation

The examiner held the pin bent at right angle. The pin or shaft of the applicator stick was slightly placed between thumb and fingerprint. The subjects were asked to close the eyes and were asked to judge whether the stimulus felt as sharp on one side as on the other. Procedure was done slowly as if testing is done too rapidly, the area of sensory change may be misjudged.

J. Touch sensation

Detailed and quantitative evaluation was accomplished using Semmes-Weinstein filament. The stimulus was given in such a way that the stimulus was not heavy enough to produce pressures on subcutaneous tissues. The examiner asked the subjects to close eyes and to say “yes” or “no” on feeling the stimulus or to name or point the area stimulated.

Fig. 2. Assessment of touch using monofilament

K. Tactile localization

The test procedure was explained to the subjects. The tactile localization was assessed using monofilament according to dermatome levels. The subject was asked to indicate the point with his/her own finger with closed eyes.

L. Temperature sensation

The examiner took two test tubes containing warm and cold water. Ideally, for testing cold, the stimuli was five degree Celsius to ten degree Celsius. For warmth, the stimuli should be forty degree Celsius to forty five degree Celsius. The tubes was dry, as dampness may be interpreted as cold. Then the examiner checked whether the subjects could distinguish between warm and cold stimuli with closed eyes.

Fig. 3. Assessment of temperature using test tubes

M. Two-point discrimination

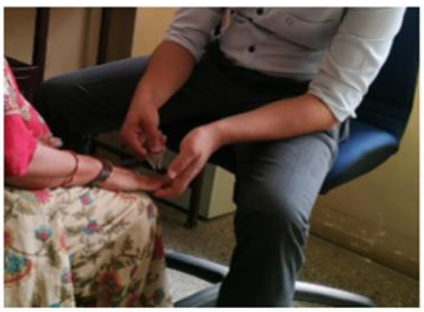

Fig. 4. Two-point discrimination

The test procedure was explained to the patient and the sensation was illustrated to him/her by touching his/her finger

with a widely separated aesthesiometer. The subjects were asked to close the eyes and the examiner touched the tip of the finger, palm, dorsum of finger and back of the hand with either one point or two point. Test was started with as far apart and approximating them until he/she begins to make error. Two-point discrimination was assessed using aesthesiometer.

N. Graphesthesia

The test procedure was explained to the subjects. The patient was asked to close the eyes, then letters or numbers were traced on the palm of the hand, arm, and forearm. Clear numbers or letters were used which can be easily answered during examination.

O. Stereognosis

The test procedure was explained to the patient. The patient was asked to close the eyes and easily accessible object (coin, pen, pencil) is given in the hand of the subject. If subject was taking too long or not able to identify, it was compared with other hand and comparison was made with speed and accuracy of response.

Fig. 5. Stereognosis assessment

P. Vibration

The tuning fork of one hundred and twenty hertz was used. The fork was placed at bony prominence after striking it hard. The placement of fork was started from the distal segment (styloid process of the radius and ulna) and moved proximally (olecranon process). The subjects were asked if he/she could feel the vibration and asked to say when the vibration stops. Stop watch was used to compare the duration of time of vibration and speed. Both the sides were compared.

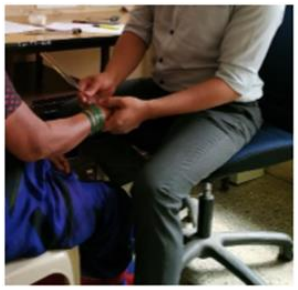

Fig. 6. Vibration assessment

Q. Statistical analysis

Graphs and tables have been generated using Microsoft Excel 2013. Data has been derived using descriptive statistics. For the categorical variables, the data was projected as frequencies and percentages.

3. Results

A. Pain

All the 60 subjects were having normal pain sensation in all the dermatome level on both the side. It was checked in 7 different dermatomes of entire upper limb. The subjects were assessed and documented where if the subject did not have any pain sensation was numerically represented as 0 and if subject had intact pain sensation was represented as 7 because it was assessed in 7 dermatomes that was entire upper limb.

Table 1
Frequency and percentage of pain

Right	Left	Frequency	Percentage
7	7	100	100.00

B. Touch

The subjects were assessed and documented where if the subject did not have any touch sensation was numerically represented as 0 and if subject had intact touch sensation was represented as 7 because it was assessed in 7 dermatomes that was entire upper limb. The number between 0-7 indicates the dermatomes where the touch sensation was present in right or left respectively.

Table 2
Variation of touch sensation in subjects

Right	Left	Frequency	Percentage
0	0	5	8.33
1	1	2	3.33
2	7	1	1.67
3	3	3	5.00
4	4	2	3.33
5	4	2	3.33
6	6	1	1.67
7	0	2	3.33
7	2	1	1.67
7	3	1	1.67
7	4	1	1.67
7	7	39	65.00
Total		60	100.00

C. Temperature

The subjects recruited were assessed and documented where if the subject did not have any sense of temperature was numerically represented as 0 and if subject had intact sense of temperature was represented as 7 because it was assessed in 7 dermatomes that was entire upper limb. The number between 0-7 indicates the dermatomes where the sense of temperature was present in right or left respectively.

D. Tactile localization

The subjects recruited were assessed and documented where if the subject did not have any tactile localization was numerically represented as 0 and if subject had intact tactile localization was represented as 7 because it was assessed in 7

dermatomes that was entire upper limb. The number between 0-7 indicates the dermatomes where tactile localization was present in right or left respectively.

Table 3
Variation of temperature sense in subjects

Right	Left	Frequency	Percentage
0	0	13	21.67
1	2	1	1.67
1	5	1	1.67
3	2	1	1.67
3	3	1	1.67
3	4	1	1.67
4	3	1	1.67
4	5	1	1.67
5	4	1	1.67
6	5	1	1.67
7	0	2	3.33
7	4	1	1.67
7	6	1	1.67
7	7	34	56.67
Total		60	100.00

Table 4
Variation of tactile localization in subjects

Right	Left	Frequency	Percentage
0	0	6	10.00
2	1	1	1.67
2	2	2	3.33
4	4	2	3.33
4	7	1	1.67
6	5	1	1.67
7	0	2	3.33
7	3	1	1.67
7	7	44	73.33
Total		60	100.00

E. Graphesthesia

The subjects recruited were assessed and documented where if the subject did not have graphesthesia sensation was numerically represented as 0 and if subject had intact graphesthesia was represented as 3 because it was assessed in 3 area of upper limb. The number between 0-3 indicates the area where the graphesthesia was present in right or left respectively.

Table 5
Variation of graphesthesia in subjects

Right	Left	Frequency	Percentage
0	0	4	6.67
0	1	1	1.67
1	0	1	1.67
1	1	3	5.00
1	2	1	1.67
1	3	3	5.00
2	0	2	3.33
2	1	3	5.00
2	2	2	3.33
2	3	2	3.33
3	1	3	5.00
3	2	2	3.33
3	3	33	55.00
Total		60	100.00

F. Vibration

The subjects recruited were assessed and documented where if the subject did not have sense of vibration was numerically represented as 0 and if subject had intact sense of vibration was represented as 3 because it was assessed in 3 area of upper limb. The number between 0-3 indicates the area where the vibration was present in right or left respectively.

Table 6
Variation in vibration in subjects

Right	Left	Frequency	Percentage
0	0	9	15.00
1	1	5	8.33
2	1	2	3.33
2	2	1	1.67
3	2	2	3.33
3	3	41	68.33
Total		60	100.00

G. Stereognosis

The subjects recruited were assessed and documented where if the subject did not have sense of stereognosis was numerically represented as 0 and if subject had intact sense of stereognosis was represented as 3 because it was assessed in 3 area of upper limb. The number between 0-3 indicates the area where the stereognosis was present in right or left respectively.

Table 7
Variation of stereognosis in subjects

Right	Left	Frequency	Percentage
0	0	9	15.00
1	0	2	3.33
1	1	8	13.33
2	2	4	6.67
3	3	37	61.67
Total		60	100.00

H. Two-point discrimination

The subjects recruited were assessed and documented where if the subject was not able to detect two points was numerically represented as 0 and if subject had intact sense of two-point discrimination was represented as 4 because it was assessed in 4 area of upper limb. The number between 0-4 indicates the area where two-point discrimination was present in right or left respectively.

Table 8
Variation in two-point discrimination in subjects

Right	Left	Frequency	Percentage
0	0	14	23.33
0	4	1	1.66
1	0	1	1.66
1	1	3	5
1	3	1	1.66
1	4	1	1.66
2	1	2	3.33
2	2	7	11.66
2	4	1	1.66
3	3	5	8.33
4	4	24	40
Total		60	100.00

4. Discussion

The objective of the study was to assess the extent and severity of the sensory impairment on the upper extremity. As recommended by the ADA a diagnosis of peripheral neuropathy can be made only after a careful clinical examination with more than one test.42Diabetes has variety of clinical symptoms in different system of the body including sensory system. So the study was done to know the facts of the sensory involvement in upper extremity in patients with type 2 diabetes mellitus.

The examination was carried out in subjects with type 2 diabetes having history of more than ten years on all the dermatomes starting from C3 to T1 on both the sides of upper extremity. Subjects recruited were screened as per the inclusion and exclusion criteria for the study.

This study suggested that two-point discrimination was most affected component in majority of the subjects. Although the method is subjective, because the patient must report whether the pressure was felt, it is more reliable than previously available methods and it is a quantitative measure of the sensory loss, which is also supported by Siemionow et al.43 which reported that TPD has been used as a tool to measure sensory loss in DM and was suggested to be a reliable quantitative measure of sensibility.

The present study indicated that pain sensation was normal for all subjects. This could be because pain, which is carried by myelinated small nerve fibers were not affected in most of the subjects as it was indicated by their NCV reports. This is an agreement with the study done by Kincaid, J. et.al.44

The study subjects were apprehensive about the pain assessment and hesitated to continue the further assessment. So, the problem could be overcome by performing the other tests prior to the pain assessment.

5. Conclusion

The current study concludes that two-point discrimination was most affected component. Pain was the unaffected sensory component. The most to least affected components were graphesthesia, temperature, stereognosis, touch, vibration and tactile localisation respectively. This suggests that there were some degree of sensory involvement in upper extremity in type 2 diabetic subjects and equal importance should be given to upper extremity while assessing the neuropathy along with lower extremity.

6. Summary

The aim of the study was to it assess the extent and the severity of sensory involvement in type 2 diabetes mellitus. A total of 60 subjects having history of type 2 diabetes were recruited for the study. The written informed consent and institutional ethical clearance were obtained.

The subjects underwent thorough sensory evaluation which included assessment for pain, touch, tactile localization, temperature, two-point discrimination, stereognosis, vibration and graphesthesia. The data was described using descriptive statistics. Pain was the unaffected sensory component. 60% of subjects had impaired two-point discrimination. Touch, temperature, tactile localisation, graphesthesia, vibration and stereognosis were also affected by 35%, 44%, 27%, 45%, 32% and 39% respectively.

The current study concluded that two-point discrimination was most affected component, pain was the unaffected sensory component. The most to least affected components were graphesthesia, temperature, stereognosis, touch, vibration and tactile localisation respectively. This suggests that there is some degree of sensory involvement in upper extremity in type 2 diabetic subjects and equal importance should be given to upper extremity while assessing the neuropathy related issues in lower extremity.

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