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# Semmes Weinstein monofilament test for detection of diabetic peripheral neuropathy: sensitivity and specificity

Vishnumoorthy Aithal<sup>1</sup> and Smitha Bhat<sup>2\*</sup>

## Abstract

**Background** Peripheral neuropathy predisposes to diabetic foot and this predilection is worsened by poorly controlled sugars. Diabetic foot increases the mortality and morbidity associated with diabetes. Thus, it is crucial to screen for diabetic polyneuropathy. Early detection of diabetic polyneuropathy improves foot care and decreases morbidity. This study aimed to assess the sensitivity of Semmes Weinstein monofilament test in the diagnosis of Diabetic Peripheral Neuropathy. Forty-three Type 2 diabetes mellitus patients availing IP/OP services of a Medical College Hospital were included for the study. Patients underwent Semmes Weinstein monofilament test, following which they were subjected to nerve conduction study of both lower limbs.

**Results** Forty six and half percentage of patients had diabetic peripheral neuropathy, taking NCS as gold standard. Of these 80% of the cases were also detected by the monofilament test. The specificity of the monofilament test was 100%. Positive predictive value was 100% and negative predictive value was 85.19% and the overall accuracy of the test was 90.7%.

**Conclusions** In this study, we found that sensitivity and specificity of the SWM test are fairly high; thus, it can be used as a valid screening tool for DPN in resource limited settings, such as India.

**Keywords** Diabetes, Neuropathy, Monofilament test

## Background

The prevalence of Diabetes mellitus in the world and in the India is increasing. Chronic microvascular and macrovascular consequences of Type 2 Diabetes mellitus include diabetic retinopathy, diabetic nephropathy and neuropathy, cardiovascular, cerebrovascular and peripheral vascular disease [1]. Peripheral neuropathy predisposes to diabetic foot and this predilection is worsened by poorly controlled sugars. Diabetic foot increases the mortality and morbidity associated with diabetes. Thus,

it is crucial to screen for diabetic polyneuropathy. Early detection of diabetic polyneuropathy improves foot care and decreases morbidity [2].

## Methods

A cross-sectional study done over a period of 3 months which included 43 Type 2 diabetes mellitus patients availing IP/OP services of tertiary care hospital were included for the study after obtaining clearance from the institutional ethical committee and written informed consent, including consent for publication from patients. Father Muller IEC approval number FMMCIEC/CCM/576/2018 dated 22/10/2018.

Objectives of the study was to assess the sensitivity of Semmes Weinstein monofilament test in the diagnosis of Diabetic Peripheral Neuropathy.

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Patients with Type 2 diabetes mellitus as per ADA criteria were included in the study.

A1C  $\geq 6.5\%$ .

FPG  $\geq 126$  mg/dL (7 mmol/L)

2-h plasma glucose  $\geq 200$  mg/dL (11.1 mmol/L) during an OGTT.

In a patient with classic symptoms of hyperglycaemia or hyperglycaemic crisis, a random plasma glucose  $\geq 200$  mg/dL (11.1 mmol/L).

Patients with past history of cerebrovascular vascular accident, Alcohol dependence syndrome defined by CAGE criteria and Lower limb amputation were excluded from the study.

Patients who fulfilled the inclusion criteria underwent Semmes Weinstein monofilament test, performed by the investigator. Following this patients were subjected to Nerve Conduction Study (NCS) of both the lower limbs. NCS was performed by a neurologist, who was blinded to patient details. The Semmes–Weinstein monofilament test kit was used to check sensory thresholds of feet. The patient was seated comfortably on a stool and requested to close his/her eyes. Two sites on the dorsum surface of the foot and one on the heel were tested on both feet, as per the method practised by A. Mythili and colleagues [3]. The monofilament was applied to the surface area of skin perpendicular to it. Following this, slight and steady pressure was applied until the monofilament began to bend. Patient raised the right hand to indicate that the monofilament touch sensation was perceived. This was considered the end point of the test. Inability to sense at one or more site on either foot was recorded as abnormal response (Fig. 1). Following this, NCS was

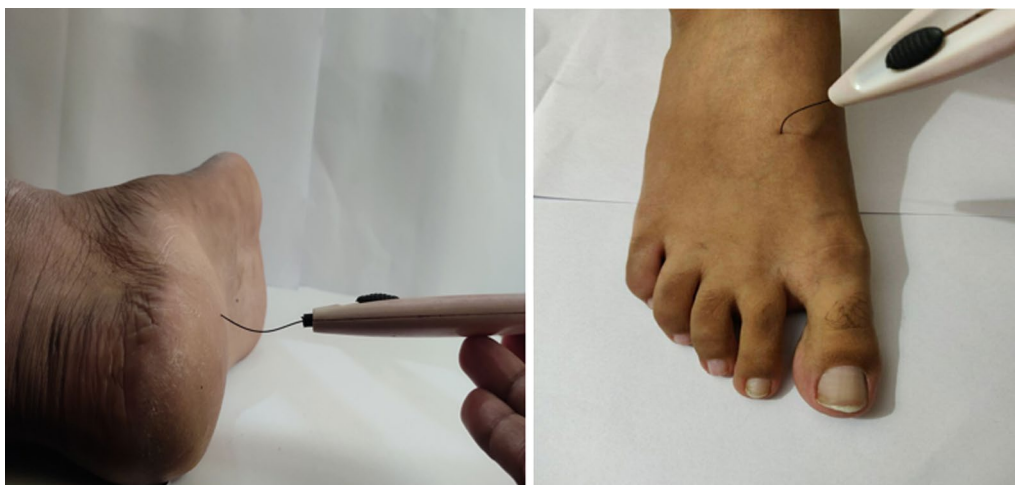
performed with the Nihon Kohden neuropack (MEB 9200 K country of origin Japan). Nerves tested were common peroneal nerve, tibial nerve, sural nerve. Parameters recorded were distal latency, amplitude of CMAP, duration of CMAP, F wave latency and conduction velocity. Considering NCS as the gold standard, the sensitivity of Semmes Weinstein monofilament test in detecting Diabetic neuropathy was calculated. Data was analysed by frequency, percentage, sensitivity, specificity, PPV, NPV, chi square test with help of SPSS software (SPSS 26 2018 developed by IBM, US based).

## Results

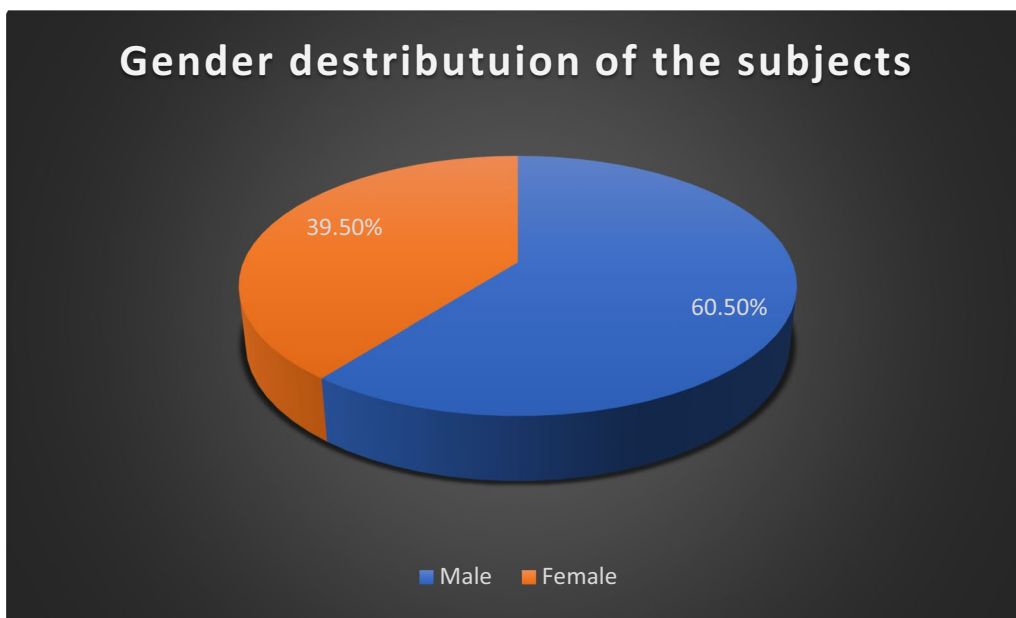
Of the 43 patients, most were in the 61–70 years age group (34.9% of the patients—Table 1). Males were 60.5% and females were 39.5% of the study population (Fig. 2). In 24% of the study population diabetes was newly detected whereas 39.5% of the patients had more than 5 years of diabetes and in 36.5% duration was less than 5 years (Fig. 3). Overweight or obesity was seen in 30.2% of the patients (Fig. 4). Of the 43 patients 46.5% of patients had diabetic peripheral neuropathy as diagnosed by NCS. Of these, 80% of cases were also detected by the monofilament test. The

**Table 1** Age distribution of the subjects

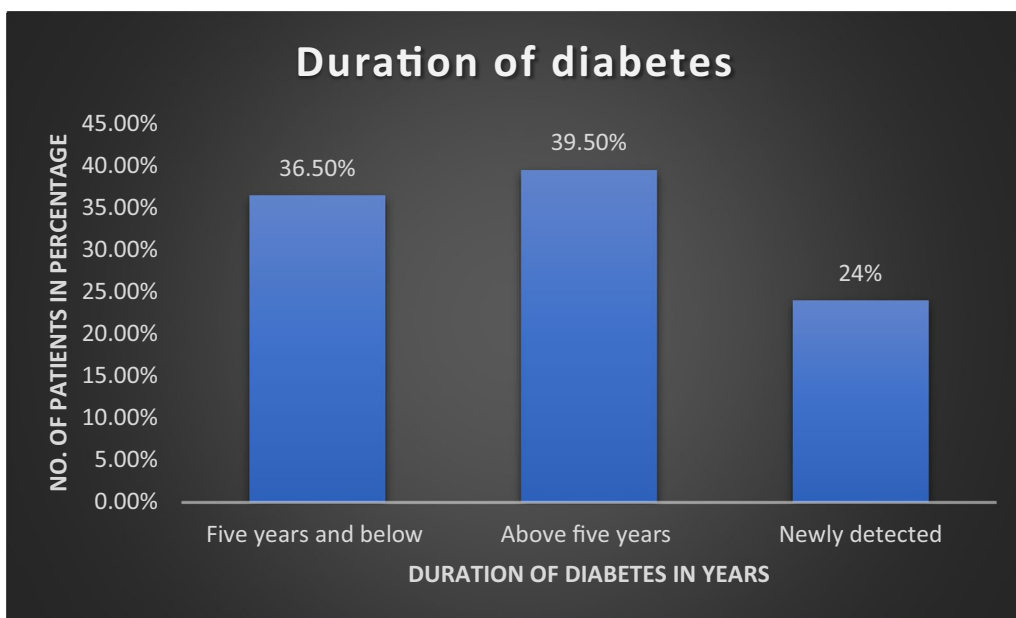
Age	Count	Percentage (%)
< 50 years	13	30.2
51–60 years	10	23.3
61–70 years	15	34.9
71–80 years	5	11.6
Total	43	100



**Fig. 1** Testing for sensation over heel and dorsum of foot



**Fig. 2** Gender distribution of the subjects

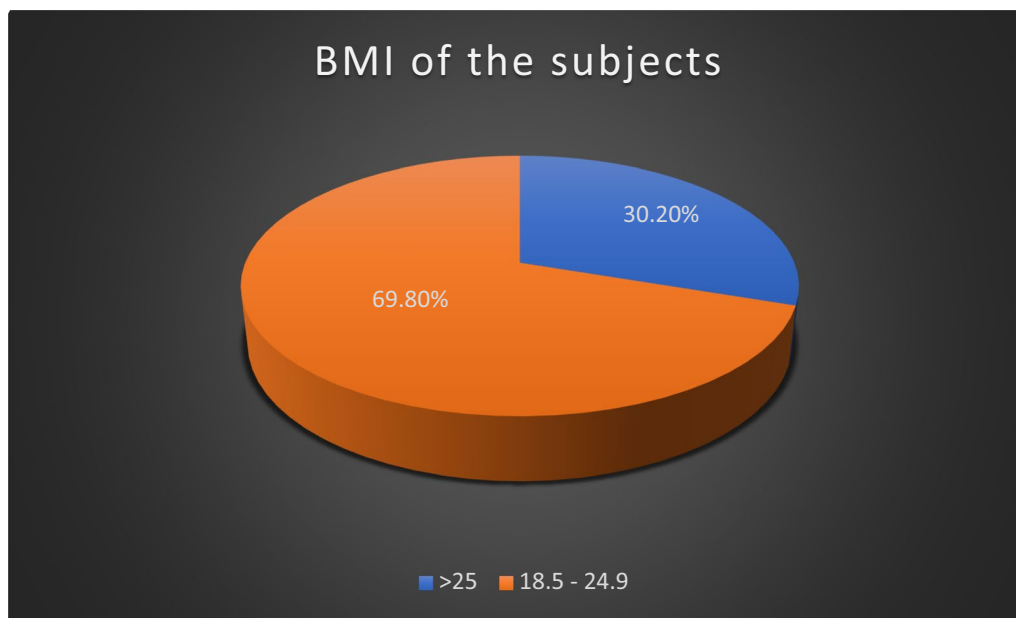


**Fig. 3** Duration of diabetes

specificity of the monofilament test was 100%. Positive predictive (PPV) value was 100% and negative predictive value (NPV) was 85.19%. The overall accuracy of the test was 90.7% (Table 2).

**Discussion**

This study aimed to find the sensitivity of Semmes Weinstein monofilament (SWM) test in identifying patients with diabetic peripheral neuropathy (DPN). We found



**Fig. 4** Body mass index of the subjects

**Table 2** Sensitivity, specificity, NPV, PPV of SWM

		Confident interval		
		Lower (%)	Upper (%)	
Sensitivity	80%	62.4	97.5	
Specificity	100%	100	100	
PPV	100%	100	100	
NPV	85.1%	71.7	98.5	
Overall Accuracy	90.7%	82	99.3	<i>P</i> =0.000, highly sensitive

PPV positive predictive value, NPV negative predictive value

that the SWM test has 80% Sensitivity; 100% specificity; PPV and NPV of 100% and 85.19%, respectively, and a total accuracy of 90.70%. DPN affects up to 50% of the patients with diabetes. Careful physical examination is essential to diagnose DPN. Essential components of diabetic foot examination include looking for ulcers, abnormality of foot shape (valgus, muscle wasting and Charcot’s) and abnormalities of skin including callus. Neurological examination includes checking for Vibration using 128 Hz tuning fork, Pin prick sensation, Ankle reflex, vibration threshold and monofilament test. However, the neurological examination can be time consuming and is limited by the fact that it is subjective. [4] Awareness of risk factors for Diabetic Foot Ulcer (DFU) is essential for prevention of diabetic foot. Prime among these factors is peripheral neuropathy. The gold standard for diagnosing peripheral neuropathy is

Nerve Conduction Study (NCS). [5] It is crucial to detect and measure sensory loss in the foot, thus identifying patients at high risk for DFU early in the course of disease. This would also facilitate planning for appropriate intervention. A study done in Austria showed only 67% specificity and sensitivity for SWM test [6]. These results suggested that when NCS was not available, pressure specified sensory device was preferable to the less sensitive SWM for detection of DPN. However this study differed from ours, the mean duration of diabetes in our patients was 4.5 years, as opposed to the Austrian study where the duration of diabetes was 12.2±10.3 years. A study done in Nepal showed that the sensitivity and specificity of SWM was 92% and 95.8%, respectively; however, this was dependent on number of sites tested. The discrepancy in results may be due to the fact there is considerable variation in the sensitivity of SWM depending on methodology of testing [3, 7–9]. The importance of diabetes and its foot complications is underlined by the fact that 15% of diabetics develop diabetic foot ulcer (DFU) during their life time. Foot ulcer secondary to diabetes is the leading cause for lower limb amputations and about 80% of all nontraumatic amputations in India are secondary to diabetic foot ulcer [10]. In diabetics, 45–60% of the foot ulcers are secondary to DPN, while the others are due to a combination of ischemia and neuropathy. Patients having DPN have a sevenfold increased risk for development of DFU [11]. Patients with history of DFU have a 45% increase in 10 year mortality [12]. In India where the prevalence of diabetes and its complications

are high, early detection is key to decrease morbidity and mortality [13]. Though not all studies show sufficient correlation between NCS and monofilament testing for diagnosis of DPN, [14] in India, where the prevalence of diabetes and its complications is extremely high, monofilament testing may be used as a simple, low cost, initial screening method. This method of testing obviates the need for specialist personnel who may not be always available. Testing for protective sensation with SWM is standard of care in diabetes. Hence students, residents, nurses must be trained to do the same at diagnosis and follow up.

### Conclusion

In this study we found that sensitivity and specificity of the SWM test is fairly high; thus, it can be used as a valid screening tool for DPN in resource limited settings such as India. However, in view of the sensitivity being influenced by methodology of testing, a standard operating procedure for testing DPN in Indian patients using SWM may be of benefit.

### Abbreviations

IP	Inpatient
OP	Outpatient
ADA	American Diabetes Association
T2DM	Type 2 Diabetes mellitus
CAGE questionnaire	Control/Annoyed/Guilty/Eye opener
SWM	Semmes Weinstein Monofilament
NCS	Nerve Conduction Study
DPN	Diabetic peripheral neuropathy
DFU	Diabetic foot ulcer
NPV	Negative predictive value
PPV	Positive predictive value
CMAP	Compound muscle action potential
BMI	Body Mass Index

### Acknowledgements

This study is partially based on work done for MD thesis under the aegis of Rajiv Gandhi university of health sciences

### Author contributions

VMA—initial conceptualization, collection of data, first draft of manuscript. SB—analysis of data, final draft of manuscript

### Funding

No external funding was received.

### Availability of data and materials

Study data and materials are available with the authors.

### Declarations

#### Ethics approval and consent to participate

Name of the ethics committee: Father Muller Medical College Institutional Ethics Committee, Date: 22.10.2018. Ref no.:EMMCIEC/CCM/576/2018.

#### Consent for publication

Authors have obtained written informed consent from all study subjects for study as well as publication and these documents are available with the authors.

### Competing interests

There is no conflict of interest declared.

Received: 22 May 2023 Accepted: 23 December 2023

Published online: 10 January 2024

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