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A Review on Detection of Diabetic Peripheral Neuropathy

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Abstract*: Diabetic Peripheral Neuropathy (DPN) is a lifelong problem of Diabetes. The nerves that reach to the arms, legs, and feet become damaged due to high glucose level over a long period of time. It leads to loss of sensation, and sometimes pain in feet and hands. DPN increases the risk of foot ulcers and amputation. About 60% to 70% over entire humans with diabetes will ultimately generate Peripheral Neuropathy. The present study proposes different methods for detection of DPN like Touch sensation test, Pressure sensation Test, Vibration sensation test. Currently, DPN diagnosed by using three different instruments. The first is 10 g SWM (Semmes Weinstein Monofilament), second is Tuning fork, third is Biothesiometer. One more method is also used that is Nerve conduction (NC) study, which is time consuming and cost is high. Different methods have some limitation like 10 g SWM have limitations like fabricating fault and atmospheric effect. The second instrument Tuning fork has limitation like method variation means physician to physician result was varied to detect DPN. Last instrument, Biothesiometer is more expensive instrument and required a highly skilled physician. Vibration is a very important parameter to detect DPN. On the basis of vibration mechanism, level of DPN can also be identified. To overcome above limitations, a reliable, portable, easiest and valid tool is required to detect DPN.

Keywords: Diabetic Peripheral Neuropathy, Vibration sensation Test, Nerve conduction study, SWM, Pressure sensation test

I. INTRODUCTION

Due to overall changes in way of life and the general surroundings over the past years, the risk of occurrence of Diabetes mellitus (DM) is increased. According to IDF(International Diabetes Federation), Diabetes Atlas announced that the amount of person having diabetes will increase from the recent approximation of 382000000 to 5920000000 after 17 years. [1]

Two most important types concerning DM. Type 1 is insulin based diabetes yet generally discovered among youth or younger adults. Another is Type 2 is non-insulin dependent DM. It is an usual type of diabetes and related to a way of life and fatness. Due to that some issue occurs include eye damage, kidney damage, and nerve damage. Moreover, due to these issues diabetic patients have a decreased value of survival. [2] The preliminary signs of diabetes and its problems are hard to detect. Moreover, to manual issues, administration and identification of disorder cause considerable cost-effective outcome for the patients. The problem covering the overall diabetes group is how to achieve the pre-eminent concealing, and diagnosis programs in each part of the earth. [3] Every year people with type-2 diabetes mellitus spread all over the world [4], that endorsed that avoidance of DPN and preliminary detection ought change into a prime concern situation at the preliminary stage where the diabetic patients visit happen.[5] Preliminary involvement approach can prevent ulceration and elimination of limb while protecting the life of a people with diabetes[6], [7] and improving the social and valuable treatment of diabetic foot disorder.[8], [9] Occupy the gold level for detection of DPN go on with NC study, which is laborious and it needs a different patient visit. That process is costly, which cannot be prescribed for diagnosing. A straightforward method that has convenient for the daily assessment and detection of in the preeminent caution is required. [10] There is a number of methods is used to detect DPN. It contains NC evaluation and tactile perception assessment, to approve technical questionaries like MNSI (Michigan neuropathy screening instrument) or clinical examination such as a pressure sensation by using 10 g SWM, with the help of tuning fork Vibration sensation can be measured. [11], [12] An identification of probable DPN is used daily, as a NC evaluation should be performed to give the identification of DPN, which needs more hour and excessive price. Additionally, the assessment of nerve conduction abnormality becomes difficult because NC values change based on the patient's history. Whereas the detection of DPN is daily accomplished in the medicinal application, the experiments containing ankle reflex experiments and NC assessment that are needed to diagnose Diabetic Peripheral Neuropathy which has issues and difficulty of the tests can not able to classify of the severity of DPN.[13]

II. METHODS

There are several instruments is used to detect DPN. Currently doctor diagnoses DPN by using three different instruments. The first is 10 g Semmes Weinstein Monofilament instrument. This instrument is used to identify loss of Pressure sensation of Diabetic

Patients. The second is Tuning fork. Physician can able to identify loss of Vibration sensation of Diabetic Patients using Tuning fork. The physician can able to identify the presence and absence of DPN by using Tuning fork. The third is Biothesiometer. This instrument used vibration mechanism to detect the level (mild, moderate, severe) of DPN. These three methods describe briefly below.

A. Semmes-Weinstein Monofilament test(SWMT)

The SWMT is a general diagnosing tool for evaluating the loss of pressure sensation. The most common monofilament used for screening was 0.5g, 2g,10g,50g, and other different types. It shows the magnitude of the force on the filament as shown in figure 1 at the time in which monofilament is just bent. [14]

Fig 1: 10 g Semmes-Weinstein monofilament
Source: http://www.mistrymedical.com

Semmes Weinstein monofilament (SWM) instrument is used by physician who increasing pressure on the skin. Increasing pressure by pressing harder up to the point at which they begin to bend. In this manner, health care professional can predict and monitor the patient's sensory function and loss of pressure sensation. [15]

Above technique is used by author A. Dutta et al. In this technique they monitor cutaneous tissue of the foot to identify the callus formation using pressure points in shoe insole and developed mobile phone based application. [16]

Same technique is used by author F. Dabiri et al. The author designed a wireless electronic orthotics with a combination of insubstantial embedded system and non- invasive sensors shown in figure 2 which can be applied to patients with diabetes suffering from Peripheral Neuropathy. The system monitors pressure dissemination and foot locomotion underneath the feet in real time. [17]

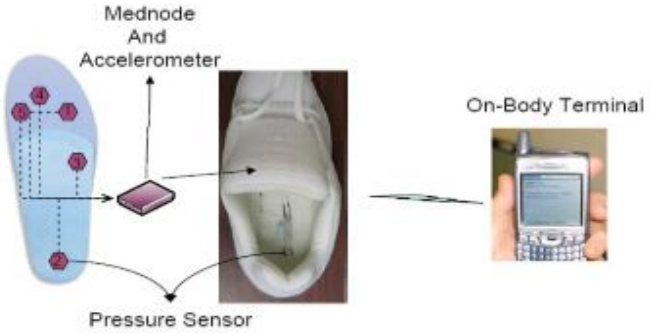

Fig 2: General architecture of the system

B. Tuning Fork

The 128 Hz tuning fork as shown in figure 3 is applied over the interphalangeal joint and asked the patient about the response. When nothing is felt than the grade is 2 point that indicates severely damaged/absent response. If the patient felt some vibration than the device is applied to the dorsal wrist. When patient feels at that point than the grade is 0 point which indicates normal. When the patient perceives stronger than the grade is 1 point which indicates a mild/moderate deficit. [18]

Fig 3: Tuning fork
Source: https://www.toolsforwellness.com

Above technique is used by author S. Ino et al. The author developed a system shown in figure 4 is composed of a plantar sensory assessment mechanism and a small scale operational contactor to elaborate the skin. One response switch is used for every sensation of touch. A personal computer and a motor control box are used for psychophysical data processing. The author identified the diagnosis of the maximum level of the skin elaborating on the plane. The author also observed leaning on stimulation site and velocity and a dissimilarity in the maximum level between normal patients and patients with an early detection of nerve damage. [19]

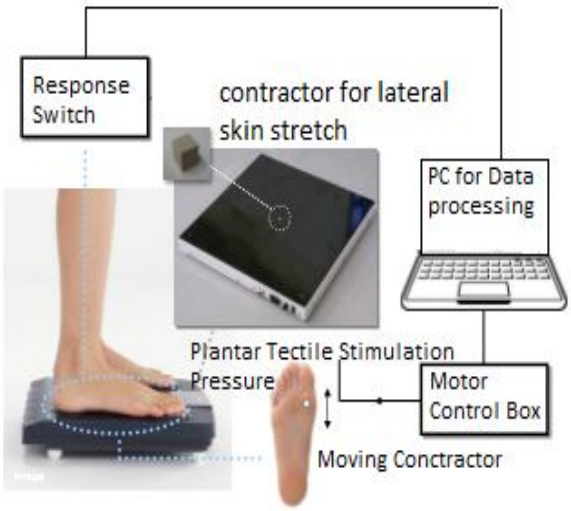

Fig 4: Simplified representation of plantar tactile assessment mechanism

Same technique is used by author J. D. May et al. In this study, author try to assess patients with diabetic peripheral neuropathy using vibrations generated from a mobile phone. Total 61 patients were tested with three different techniques the first is using 10 g Semmes Weinstein, second is tuning fork, and the third is mobile phone generated vibration. Different points were tested like a patella, medial malleoli, first and fifth metatarsal head, lateral malleoli, heel, index finger. The most accurate location for screening DPN was the 1st metatarsal head. The accuracy of the tuning fork was 0.77, 10 g monofilament was 0.79, and mobile phone accuracy was 0.88.[20]

C. Biothesiometer

The testing is started with lower limb and upper limb. If a Vibration Perception Threshold (VPT) of less than or equal to 50 V was indicated at the first location, no any other location was tested. In this method, the voltage was gradually increased from 0V at a speed of 1V/S to every extremity continuous. When patient indicated that he/she first perceived the vibration at that moment VPT was recorded. After that, voltage increases 10V above the first VPT indicated by the patient and then reduced slowly up to the point

at which patient cannot feel the vibration. The same process was then applied to record the measurement on the upper limb. An upper limb with joints of the middle finger, fingertip, wrist, and elbow were tested. The participant was prone during the testing procedure and cannot able to see the biothesiometer knob as shown in figure 5. [21]

Fig 5: Biothesiometer
Source: http://www.diabeticneuropathy.co.in

Another technique is given by C. M. Chen et al. In this technique the author used two Photoplethysmography sensors and one, two lead electrocardiography sensor is used to diagnose the dissimilarity in Pulse Arrive Time as a judgment in analyzing the development of DPN. It concludes that PAT (Pulse Arrive Time) becomes greater when a pressure was executed onto superior extremity with the use of blood pressure cuff simulating arterial toughness. [22]

III. ADVANTAGES OF EXISTING TECHNIQUES

A. Following are the advantages of existing techniques.

1) Monofilament and Tuning fork are cheap technique. By using this technique, physician can able to identify the presence and absence of DPN.

2) Biothesiometer can detect the levels of DPN. By using this technique, level of DPN (mild, moderate, severe) can be identified.

IV. DISADVANTAGES OF EXISTING TECHNIQUES

Following are the disadvantages of existing techniques.

A. 10 g Monofilament

1) *Fabricating fault :* The test and all the investigation done to encourage its use is expected on the instrument constantly applying 10 grams of pressure on the skin of the foot. Investigation on current monofilaments has shown defective standardization in force application between different industrialist. [23]

2) *Atmosphere effect:* According to temperature and humidity Nylon material is susceptible to changes in its stiffness. Due to this resulting effect is varied from the 10 gram pressure application of monofilament. [24]

B. Tuning fork

1) *Method Variation:* The Physician would hit the tuning fork and then apply it to the patient's anatomy at the same time beginning the handheld timer. The patient then indicates when the vibrations terminated beyond perception. The drawbacks are variations in the vibration of the tuning fork (different physician applying different forces, multiple industrialists making the tuning fork) and difficulty to identify accurate timing at which patient lost perception of the vibration. Due to difficulty in performing the test and lack of standardization in the test limited its clinical use.

C. Biothesiometer

This technique takes too much time. This technique does not use 128 Hz standard frequency to detect DPN. This manually control technique. Biothesiometer is a more expensive instrument and needs more experience to detect DPN.

V. CONCLUSIONS

I conclude from the literature review that 10g SWMT is not standardized technique. A lack of standardization in technique calls into question the applicability of the test results. For example, Japanese researchers have found the 2 gm monofilament more efficacious

in their patient population than the traditional 10 gram monofilament.[25] By using a tuning fork, variation in results occurs. Last instrument, Biothesiometer is a more expensive equipment and required a highly skilled physician. Recently, Vibration is a most important parameter to detect DPN. On the basis of timed vibration test, a level of DPN can also be identified. The standard frequency to detect DPN is 128 Hz. To overcome above limitations, a reliable, portable, easiest and valid tool for detecting DPN is needed.

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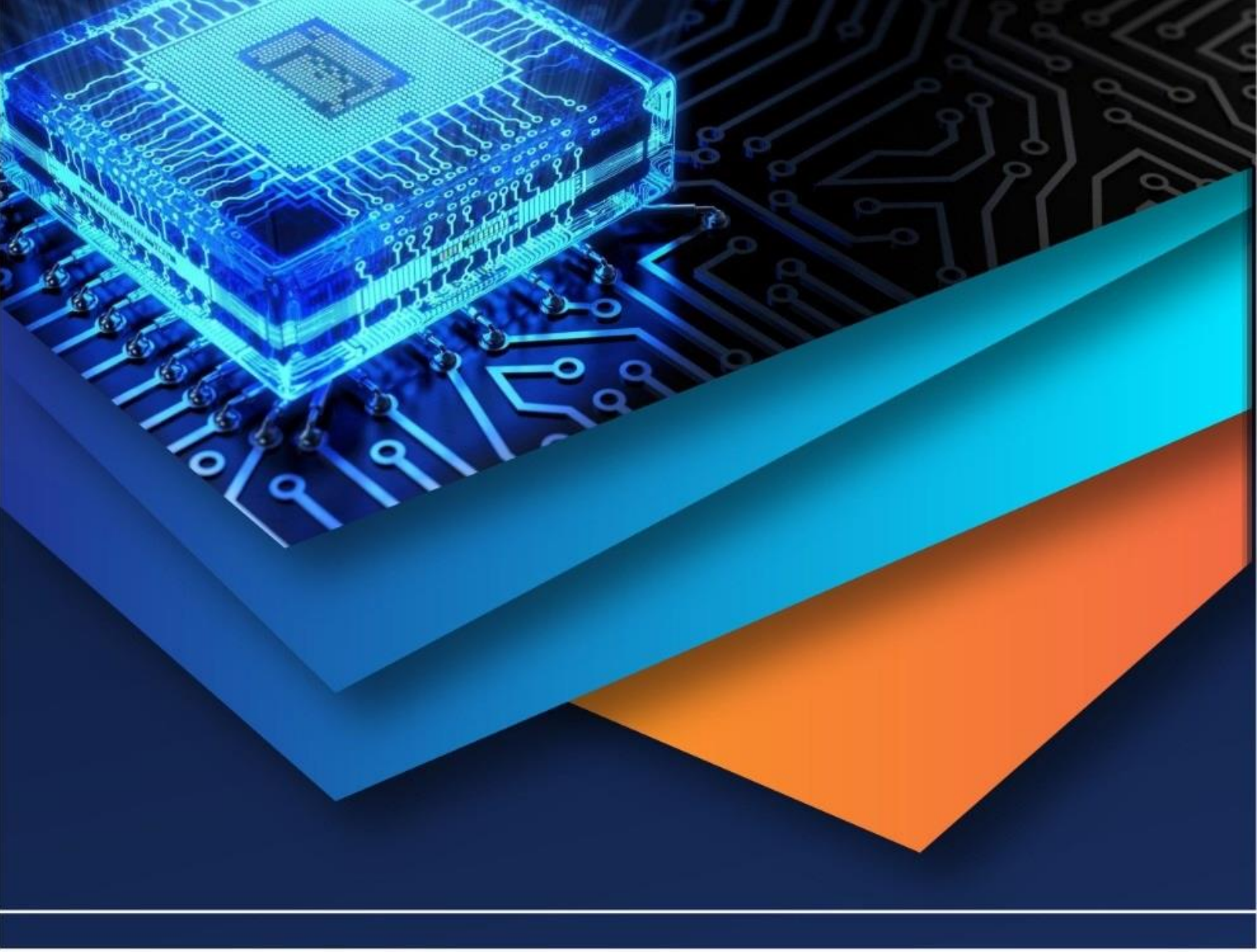

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