RESEARCH PAPER

A Devices for Measuring Vibration, Pressure, and Temperature in Sensory Dysfunction Subjects – A Narrative Review

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ABSTRACT

Background: In this era of growing world of health science at present, there is no formula or scale which is available for identification of sensory changes in sensory alteration subjects. Evidence-based practice and clinical reasoning is important day by day. Many qualitative and quantitative techniques can be applied to test Vibration, Pressure and Temperature in clinical surroundings for the evaluation and alteration of sensory function. Objective: Main Purpose of this article to find out reliability and validity of different instrument that widely used for evaluation of sensation. That helps to identify gap between subjective as well as objective.

Review Methods: Using 'Search Terms' to evaluate the articles that investigated any sensory dysfunction in any of the relevant subjects. For the analysis, their psychometric properties and clinical utility were studied. Electronic databases namely - MEDLINE, CINAHL, EMBASE, AMED, PUBMED and Google Scholar were searched up to December, 2024.Inclusion criteria encompassed studies involving neurological conditions, metabolic diseases, diabetes, or assessments of normal healthy individuals.

Conclusion: It is essential to follow all standardized protocols for the testing and interpretation purpose to ensure consistent and reliable results. Moreover, continuous calibration and maintenance of every instrument is of utmost necessity to ensure reliability and validity over time. There is also a need to develop a device that measure subjective as well as objective values.

Keywords: Sensory Evaluation, Receptor, Sensory Alteration, Instrument Assessing Sensation, Pressure, Temperature and Vibration, Importance of Sensory Examination.

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I. INTRODUCTION

Sensory information provides invaluable feedback for the evaluation as well as analytical part. It can be utilized as the ability of the brain to do organization, interpretation and use this information for identifies diagnosis as well as prognosis. This results in an internal presentation of the body. It is neurological information that use when motor task is performed by the individual, who learns to anticipate, correct or rectify any movements based on the sensory inputs arranged by the Central Nervous System (CNS).[1]

Somato-sensation is the sensations received from the skin and muscular-skeletal system. Examining the sensory function helpful for the processes and integrates the planning and organizing responses.[1, 2]

Sensory Organs respond to specific stimuli and it has two major functions as below:[3, 4, 5]

- Identify a physical or chemical stimuli for specific response.
- Using the sensory information for meaningful responses.

IMPORTANCE OF SENSORY EVALUATION [1,6,7]

Evaluation is detecting and evaluating the patient's problems and planning an available and appropriate intervention. It has three major components: History, Systems Review, and Examination. It generally begins with patient's examination after regular intervals for the better prognosis.

Examination of this function provides important information related to the diagnosis, prognosis, identifies anticipated aims, expected results and develops a Plan of Care. Different instrument shown on fig1.1 an important feature of the examination process includes determination of the pattern of sensory involvement. Sensory alteration or deficits may occur anywhere within the system of human body. [8]

Reliability of these test procedures is based on the examiner conducting the procedure with the use of proper guidelines, Conduct of the tests by trained professionals,

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and consequent re-tests performed by the same examiner.[9,10] Development of the Quantitative techniques, standard protocols, that help to measures for reliability, and additional normative data are good for the planning of the rehabilitation protocol.[11]

Examination of sensory function contributes critical information for analysis and diagnosis. An important feature of the examination includes determining the pattern of sensory involvement. Periodic re-examination provides critical data on changes in the status of the patient and in determining progress toward the aims and outcomes.

Fig: 1.1 Shows quantitative sensory testing tool

Aage R. Moller, 2003, highlighted that additional research related to the development of QST techniques, standardized protocols, reliability measures, and additional normative data will significantly better the clinical applications of data obtained from the examination of sensory function.[1,2] there are certain existing devices which measure temperature, pressure & vibration as follows:

VIBRATION: [1,4,7,11,15]

Bio-thesiometer: A Bio-thesiometer is an instrument designed to measure the sensitivity to vibratory stimuli in a quantitative manner. This handheld device applies vibrations to the skin, with the intensity either preset or gradually adjusted. The stimulation can be increased until it is perceived by the user or decreased until it is no longer felt.

Rydel-Seiffer 64/128 Hz Graduated Tuning Fork: Tuning Fork is a precise instrument equipped with small weights on the distal ends of its prongs, allowing it to switch from specific range. The point at which the patient no longer perceives that dermatome noted.

Vibrameter: A Vibrameter is a device used to quantitatively measure vibrations. Testing points include areas such as the dorsum of the metacarpal bone of the index finger, the first metatarsal, and the tibia. The handheld device applies the stimulus, and the data is automatically stored in a computer database.

Vibratron II: It is also known as the Vibratory Sensory Analyzer, is a handheld device designed to measure a patient's Vibration Perception Threshold (VPT). It features a vibrating probe connected to a control unit, which is applied to specific anatomical sites such as the fingertips or toes. The vibration intensity is gradually increased until the patient perceives the sensation. The control unit enables the clinician to adjust the vibration intensity and record the VPT. It offers a range of adjustable vibration frequencies and amplitudes, allowing customization according to the patient's needs. It often includes a digital display for real-time feedback and data recording. This device is utilized in clinical settings to assess vibration perception thresholds in patients with sensory impairments, neuropathies, or neurological disorders. It provides quantitative measurements of vibration sensation, aiding in diagnosis, treatment planning, and monitoring of sensory function. It demonstrated reliability and validity in measuring vibration perception thresholds, with studies showing good agreement with other gold standard methods. To ensure consistent and reliable results, it is essential to follow standardized testing protocols, including proper probe placement, vibration frequency, and patient positioning.

Vibration Sensory Threshold Testing Devices: Vibration Sensory Threshold Testing Devices are electronic tools designed to measure Vibration Perception Thresholds (VPT). These devices usually consist of vibrating probes or pads connected to digital control units that deliver standardized vibration stimuli and record sensory responses.

Instruments such as the Vibratron II offer clinicians valuable means for evaluating vibration sensation in physiotherapy settings. By accurately measuring vibration perception thresholds, clinicians gain insights into patients' sensory functions, allowing them to tailor treatment interventions and monitor changes in sensory status over time.

PRESSURE: [1,4,7,11,12,13]

The therapist, using his/her fingertip or cotton swab, applies firm pressure to the patient's skin, ensuring that the pressure is sufficient to palpate the skin and stimulate the deep skin receptors. Alternatively, the therapist can use their thumb and fingers to squeeze a tendon. The patient is instructed to respond with "yes" or "no" when they feel the stimulation.

Analog Pressure Algometry: The main function similarly to electronic pressure algometry but utilizes and displays instead of digital ones. While operating on the same basic principles, this models may lack some of the advanced features found in their electronic counterparts.

Semmes-Weinstein Monofilaments: Semmes-Weinstein Monofilaments are handheld devices equipped with multiple nylon filaments of varying thicknesses that apply precise pressure when pressed against the patient's skin. They are frequently utilized for evaluating pressure sensitivity thresholds in patients diagnosed with peripheral neuropathy.

Pressure Sensing Mats: Pressure Sensing Mats are thin and flexible mats fitted with pressure sensors to gauge how pressure is distributed and its intensity on the mat's surface. They are commonly employed to analyze pressure distribution during standing or walking activity, and to monitor ulcer pressure in patients confined to bed.

Force Plates: Force Plates, on the other hand, measure the ground reaction forces generated by a patient's feet while standing or walking. Although they aren't primarily intended for assessing pressure sensation, force plates offer valuable insights into weight distribution and balance.

TEMPERATURE: [1,4,7,11,13,14,15,16,17]

Temperature Awareness: It is testing for evaluates the ability to identify between warm and cool stimuli. This test requires two test tubes, one filled with warm water and the other with crushed ice. Optimal temperatures should maintain for cold and hot test tube. It's crucial to stay within these ranges to avoid triggering a pain response that could lead to inaccurate results.

Tip Therma: It is a tool designed for early detection of changes in skin perception that mainly use for monitoring Polyneuropathies associated with diabetes. It allows patients to independently test the temperature sensitivity. The instrument measures approximately 4 inches (100 mm) in length and has a diameter of about 0.59 inches (15 mm).

TSA-II Thermal Sensory Analyzer + VSA 3000: It is a computer-controlled system that can administer and record responses to repetitive vibratory and thermal stimuli. The system records sensory thresholds and compares them to age-matched normative data stored in the computer.

Temperature Discrimination Wheel: A Temperature Discrimination Wheel is a straightforward tool comprising a rotating disk marked with various temperature zones (e.g., warm, cool, neutral). Patients touch the disk and identify the perceived temperature zone. This tool is ideally suited for evaluating temperature discrimination and perception in individuals with sensory deficits or impairments.

In today's rapidly advancing field of health and medical science, there is currently no standardized formula or scale to identify sensory changes in subject with sensory dysfunction. Clinicians can proactively intervene by educating patients on preventive measures and lifestyle modifications.

It is crucial to educate individuals with sensory changes instruct about daily foot inspection, appropriate levels of weight-bearing activities, selecting suitable footwear, and monitoring sensitive pressure areas to enhance overall life expectancy. Therefore, there is a critical need for objective criteria to assess sensory changes in diabetic patients, benchmarked against normative reference values of healthy individuals.

II. METHODOLOGY

Design:

An observational, Analytical study done with the help of reviewing various article based on specific criteria using databases such as Medline, Embase, and Google Scholar (2015-2024). Ethical Clearance obtained by institute. The search query focused on identifying papers whose titles or abstracts included keywords related to sensory dysfunction, devices for measuring temperature, pressure, and vibration, the significance of sensory evaluation, neurological disorders, and methods for sensory examination.

Data collection Tool:

A total of 126 articles were reviewed according to these criteria.[11,14,18]

Inclusion criteria encompassed studies involving neurological conditions, metabolic diseases, diabetes, or assessments of normal healthy individuals. Exclusion criteria excluded articles focusing on histories of drug or alcohol abuse, vitamin B1 or B12 deficiencies. Articles were further excluded if they lacked analyses of validity, reliability, or diagnostic accuracy, or if such analyses could not be conducted with the available data.[18,19,20,21,22,23,24]

A descriptive analysis done based on the all the article and summaries according to that. A total of 126 articles were assessed according to the criteria, with 22 articles excluded due to lacking adequate information on reliability and validity values.[22, 23, 24]

A Statistical analysis was done by using of Microsoft Excel.

Table 3.1 presents the reliability and validity values for instruments measuring pressure, temperature, and vibration.[21, 22,23,24,25,26,27,28,29,30]

Sr. No.	Instrument	Reliability (Icc)	Validity(Icc)
Pressure			
1.	Bio-Thesiometer	0.74	0.77-0.94
2.	Analog Pressure Algometer	0.73-0.74	0.84-0.99
3.	Semmes-Weinstein Monofilaments	0.74	0.89-0.93
4.	Pressure Sensing Mats	0.79	0.70-0.67
5.	Force Plates [31]	0.89	0.78-0.83
Vibration			
1.	Tuning Fork	0.52	0.85-0.95
2.	Vibrameter [32]	0.79	0.51-0.63
3.	Vibration II Vibratory Sensory Analyzer	0.96	0.67-0.63
4.	Vibratory Sensory Threshold Device [33]	0.67	0.54-0.65
Temperature			
1.	Tip Therma	0.87	0.79-0.85
2.	TSA-II Thermal Sensory Analyzer [25]	0.56	0.50-0.63
3.	VSA 3000	0.87	0.91-0.98
4.	Temperature Discrimination Wheel. [31,32,33]	0.76	Still Not Identify

III. DISCUSSION

This study focuses on measurement errors, considering both device and examiner factors, with and without human influences. Primary objective of the study involves a very thorough assessment of reliability and validity of instruments as mentioned in the table 3.1. Previous research has not established reference values specific to instrument-focused measurements.

According to the National Diabetes Survey (2013), around 60-70 percent of individuals with diabetes diagnosed with neuropathy. Neuropathy. Nerve-related issues can develop at any stage of diabetes, with risks increasing with age and longer disease duration. The highest incidence of neuropathy occurs in individuals who have had diabetes for at least 25 years.[28]

Talal H. Salame's study published in The Open Dentistry Journal (2018) that identify QST methods utilizing thermal stimuli can effectively assess sensory dysfunction in orofacial pain patients, focusing on specific parameters such as cool and warm sensations, as well as cold and hot pain.[30]

Prashant Mathur's 2022 study examines the prevalence, awareness, treatment, and control of disease in India based on nationwide monitoring systems. The study advocates for multifaceted approaches to improve awareness, adherence to treatment, and preventive counseling services to curb the diabetes epidemic.[32]

A limitation of this study is its focus solely on measuring sensations in the foot. Future research should expand to

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measure sensations comprehensively and develop normative values to detect abnormalities more effectively.

IV. CONCLUSION

The review identified numerous technology-assisted methods and their related outcome measures for evaluating sensory dysfunctions. However, these methods seem to lack a systematic evaluation of their psychometric properties. Therefore, there is a need to consolidate knowledge regarding current approaches, as no fully validated alternative to existing clinical scales or devices is readily available. Developing a device capable of measuring both subjective and objective values to assess sensation is warranted.

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Conflict of Interest:
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Ethical Clearance:
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Author Contributions and Guarantor Statement:
I conducted the research, contributed to the discussion, and drafted the initial version of the manuscript.

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