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Normative Values of Vibration Perception Threshold (VPT) In Young Adults

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ABSTRACT

Background: Impaired vibratory perception is an early, frequent finding in various neuropathies. Though normative data for Vibration Perception Threshold (VPT) is documented in elderly adults, no such data is available in young adults.

Aim: To obtain normative values for the VPT in the lower extremities, to evaluate VPT variability between the sites, sides and to study the correlation of VPT with sex and BMI in healthy young adults.

Methods: 80 healthy young adults (35 males and 45 females), aged 18-25 yrs (21.09±3.69yrs) were recruited from the student population of M.S.Ramaiah Medical College. VPTs were measured using Sensitometer-VPT, at 16 specific sites in both the lower extremities. The Sensitometer Probe was applied over predetermined sites and voltage was steadily increased. The voltage at which the subject experienced the sensation of vibration was noted (Simple Up/Down method). The mean of 3 readings at each site was considered for analysis. Mean vibration thresholds were compared by student t-test.

Results: The range for VPT values found was 4.97-12.98 volts. (2.5^{th} - 97.5^{th} percentile). There was no significant difference in the VPT values between sites and the right and left sides. Also there was no significant correlation of VPT with sex and BMI ($P>0.05$).

Conclusion: These normative values of VPT can serve as a basis for future clinical applications of VPT measurements in young adults.

Keywords: Vibration perception threshold, T2DM, diabetic neuropathy

INTRODUCTION

Vibration Perception Threshold (VPT), which measures the minimal level of vibratory sensation, is a valuable diagnostic tool for assessing peripheral nerve damage. Impaired vibratory perception is a critical indicator of early sensory nerve dysfunction, particularly relevant in the context of rising younger-onset diabetes. VPT screening in young adults is crucial for the early detection of neuropathies, including diabetic neuropathy, multiple sclerosis, and other neurological disorders. Early identification facilitates timely interventions, such as improved glycemic control and lifestyle modifications, to slow disease progression and prevent complications. [1-4] .

Existing literature has established normative VPT data in elderly populations, highlighting how vibratory perception changes with age. For instance, studies have shown that older adults exhibit significantly higher VPTs compared to younger cohorts, reflecting a decline in sensory nerve function over time [5-6]. Research indicates that as individuals grow older, their ability to detect vibration decreases, which correlates with physiological changes in nerve conduction and alterations in skin properties, leading to increased VPT values [7-8].

Despite the valuable insights gained from studies on older adults, there remains a significant gap in normative data for VPT specific to young adults. The lack of baseline information for this demographic poses challenges in clinical interpretation, making it difficult to distinguish between normal variations and potential pathologies when evaluating young patients. Young adults can also experience conditions affecting their peripheral nerves, including metabolic and nutritional factors, but without established normative values, sensory impairment may go unnoticed or be misdiagnosed [9].

Several demographic factors can influence VPT, including sex and Body Mass Index (BMI). Studies have shown that VPT can vary between males and females, likely due to physiological differences in nerve anatomy and function [10-11]. Additionally, BMI may serve as a contributing factor, with research suggesting that individuals with higher BMI may have altered peripheral nerve function, potentially leading to higher VPTs [12]. Therefore, understanding how these factors correspond to normative values for VPT in young adults is essential for accurate clinical assessments.

Variability in VPT based on anatomical sites is another important consideration. Previous studies indicate that different regions of the body exhibit distinct VPTs, with areas such as the great toe generally having lower thresholds compared to other locations, such as the ankle [13-14]. This variability highlights the need for site-specific normative data, which can enhance the understanding of sensory nerve function across different anatomical locations.

This study aims to establish normative Vibration Perception Threshold (VPT) values for the lower extremities in healthy young adults, addressing a critical gap in the literature. By evaluating VPT at multiple sites; [great toe (GT), first metatarsal head (I MTH), third metatarsal head (3rd MTH), fifth metatarsal head (5th MTH), midarch, heel, dorsum and ankle] and considering factors like sex, BMI, and laterality, this research will provide a comprehensive understanding of vibratory perception in this population. These findings will not only contribute to a more complete understanding of age-related VPT changes but also have significant clinical implications for early detection and intervention strategies for sensory nerve impairments in younger individuals.

MATERIALS AND METHODS

In this study, we aimed to assess the VPT in a cohort of healthy young adults, focusing on the variability of VPT across different anatomical sites in the lower extremities. A total of 80 participants, comprising 35 males and 45 females, were recruited from the student population of M.S. Ramaiah Medical College, Bengaluru, India. The age range of participants was between 18 and 25 years, with a mean age of 21.09 (±3.69) years. Inclusion criteria were based on the absence of any known neurological disorders, metabolic conditions (such as diabetes), or any factors affecting peripheral nerve function, including recent history of lower extremity trauma or systemic diseases.

Recruitment and Consent

Participants were recruited through flyers distributed within the college campus, and voluntary consent was obtained from each participant prior to their inclusion in the study. All methods were approved by the Institutional Ethics Committee of M.S. Ramaiah Medical College, and the study followed the principles outlined in the Declaration of Helsinki.

Measurement of Vibration Perception Threshold

VPTs were measured using a calibrated device known as the Sensitometer-VPT, specifically designed for vibration testing. The Sensitometer is an electronic device equipped with a probe that delivers vibrations at gradually increasing voltages. Before commencing the assessments, each participant underwent a brief familiarization session to ensure they understood the testing procedure and to reduce any anxiety that could affect the results.

The vibration thresholds were assessed at 16 predetermined sites on both lower extremities, which included anatomical landmarks such as the great toe, first metatarsal head, second metatarsal head, third metatarsal head, midarch, heel, dorsum and ankle. These sites were selected based on previous literature indicating their relevance in assessing VPT.

Testing Procedure

During the testing, participants were comfortably seated in a quiet environment to minimize external distractions. The sensitometer probe was applied to the first tested site, and the voltage was gradually increased in small increments. The increase in voltage was controlled by a computer interface to ensure precision. Participants were instructed to indicate as soon as they felt the sensation of vibration, at which point the voltage level was recorded. This procedure utilized the Simple Up/Down method, often acknowledged for its reliability in sensory threshold determinations.

To ensure the validity of the results, each site was measured three times with a brief rest period between tests to avoid sensory fatigue. The mean of the three recorded readings for each site was calculated, allowing for individual variability while minimizing the influence of transient factors like attention or fatigue.

Data Analysis

The collected data were analyzed to determine mean VPT values across all sites and to evaluate differences in VPTs based on anatomical locations, sides (left vs. right), and demographic factors such as gender. Statistical comparisons were made utilizing the Student's t-test for comparing means between groups (e.g., male vs. female participants) and site-to-site variations. The comparison of right and left sided parameters were done using paired t tests.

Statistical significance was set at $p < 0.05$, and all analyses were conducted using statistical software SPSS (version 15) to ensure robustness and repeatability of the results. Descriptive statistics, including mean and standard deviation (SD), were calculated for VPT values at each anatomical site, providing a comprehensive overview of vibratory perception within this young adult population.

Through these methods, we aimed not only to establish normative values for VPT in young adults but also to provide insights into the effects of anatomical location and demographic characteristics on vibratory perception, ultimately enhancing the understanding of sensory nerve function in healthy individuals.

RESULTS

Demographic and Physiological Parameters (Table 1)

The cohort comprised 80 participants with a mean age of 21.59 years (SD: 5.66), including 35 males and 45 females. Mean height was 163.6 cm (SD: 10.31 cm) and mean weight was 58.48 kg (SD: 12.46 kg). The average BMI was 21.82 kg/m^2 (SD: 3.72), suggesting a normal weight range for the participants.

Table 1: Demographic and Physiological Parameters

Parameters	Mean and SD
Age in years	21.59 ± 5.66
Gender	35 M; 45 F
Height in cm	163.6 ± 10.31
Weight in Kgs	58.48 ± 12.46
BMI (kg/m^2)	21.82 ± 3.72

Family History of Diabetes and Hypertension in participants (table 2)

A majority of participants (28 individuals) had no family history of diabetes or hypertension, suggesting a lower genetic risk within this group. Eight participants had a family history of diabetes only, while 21 had a history of hypertension only. Additionally, 23 participants reported a family history of both diabetes and hypertension, indicating a notable presence of these health issues among some families. This information may help assess the potential impact of genetic factors on the health outcomes of the studied individuals.

Table 2: Family History of Diabetes and Hypertension in participants.

Family History	n
Negative for Diabetes and Hypertension	28
History of Diabetes only	8
History of Hypertension only	21
History of Diabetes and Hypertension	23

Sensitometer Measurements (table 3)

VPT Measurements

The mean VPT values measured at each anatomical site in the lower extremities of the 80 healthy young adults are presented in the table below. Each value represents the average threshold voltage required for vibration perception as recorded during the testing sessions, calculated based on the mean of three trials at each site.

Specific Measurements: The greatest mean difference was observed at the **GT** measurement, with the right side averaging 8.43 and the left side at 8.17. However, the p-value of 0.12 suggests that this difference is not statistically significant. For the **1st MTH**, the means are very close (8.17 for right vs. 8.12 for left), with a p-value of 0.6, indicating no significant difference. The **3rd MTH** and **5th MTH** also show negligible differences between sides, with p-values of 0.88 and 0.87, respectively. The **Mid Arch** and **Heel** measurements show slight differences but are not significant either (p-values of 0.13 and 0.29). The **Dorsum** and **Ankle** readings similarly show no significant differences (p-values of 0.08 and 0.28).

Overall Trend: The range for VPT values were found to be 4.97-12.98 volts. (2.5^{th} - 97.5^{th} percentile). Mean sensitometer readings tend to be slightly higher on the right side than on the left in several measurements, though the differences are not statistically significant, as indicated by the high p-values (all greater than 0.05).

Table 3: Sensitometer Measurements

Sensitometer	Right Mean ± SD	Left Mean ± SD	p value
Great Toe	8.43 ± 2.4	8.17 ± 2.15	0.12
1st Metatarsal Head	8.17 ± 2.32	8.12 ± 2.18	0.6
3rd Metatarsal Head	8.06 ± 2.24	8.08 ± 2.18	0.88
5th Metatarsal Head	8.13 ± 2.18	8.11 ± 2.28	0.87
Mid Arch	7.98 ± 2.05	8.13 ± 2.16	0.13
Heel	7.98 ± 2.01	8.07 ± 2.07	0.29
Dorsum	7.99 ± 1.98	8.14 ± 2.05	0.08
Ankle	8.21 ± 2.07	8.36 ± 2.27	0.28

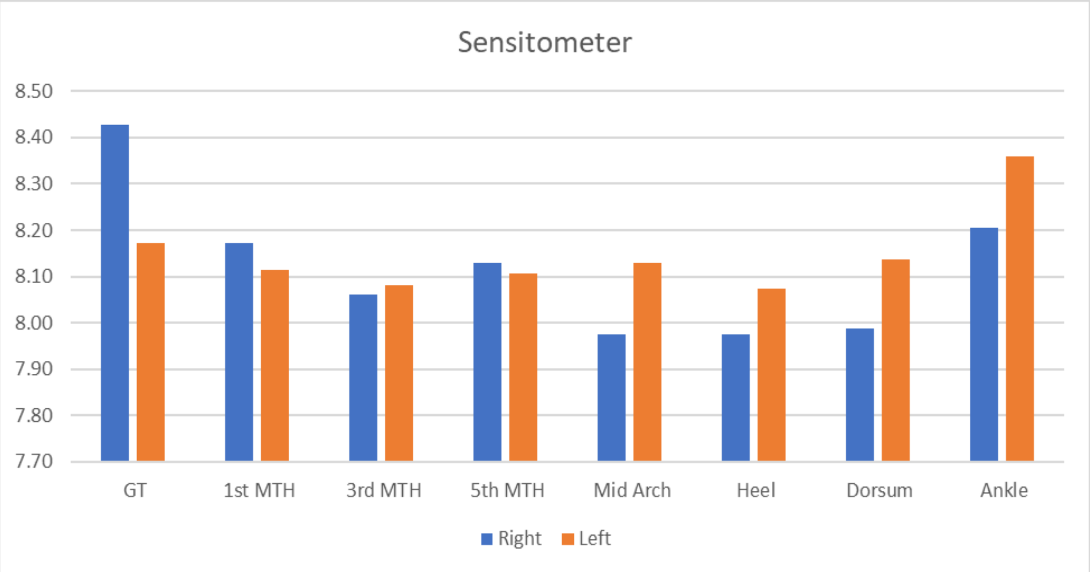

Figure 1: Sensitometer findings in right and left side in study subjects

Comparison of parameters between males and females (Table: 4)

The table presents the mean, SD, maximum, minimum, and p-value for various parameters measured in both female and male subjects. The parameters include demographic information (age, height, weight, BMI), and sensory measurements. The p-value indicates the statistical significance of the difference between males and females for each parameter. Despite potential confounding factors such as age and BMI differences between males and females, no significant differences were observed in VPT measurements.

Table: 4 : Comparison of parameters between males and females in the study

	Female (n = 45)				Male (35)				
Parameters	Mean	SD	Maximum	Minimum	Mean	SD	Maximum	Minimum	p value
Age	22.8	6.7	56.0	18.0	20.0	3.4	33.0	17.0	0.029*
Height(Cms)	156.3	6.3	170.5	143.0	173.0	5.7	181.0	160.0	0.000*
Weight(Kgs)	52.6	9.7	88.0	41.0	66.0	11.7	104.0	52.0	0.000*
BMI	21.6	3.9	36.1	17.5	22.2	3.5	32.1	16.4	0.481
R- Great Toe	8.2	2.5	16.0	4.8	8.7	2.3	14.0	3.0	0.302
R- 1st Metatarsal Head	7.9	2.4	16.0	4.8	8.5	2.1	14.0	3.0	0.334
R- 3rd Metatarsal Head	7.8	2.3	16.0	4.4	8.4	2.2	14.0	3.0	0.197
R- 5th Metatarsal Head	8.0	2.3	16.0	5.0	8.3	2.0	14.0	3.0	0.574
R- Mid Arch	7.9	2.2	16.0	5.0	8.1	1.9	12.0	3.0	0.673
R- Heel	7.8	2.1	16.0	5.0	8.2	1.9	12.0	3.0	0.380
R- Dorsum	7.8	2.1	16.0	5.0	8.2	1.8	12.0	3.0	0.400
R- Ankle	8.0	2.2	16.0	5.0	8.5	1.9	13.0	3.0	0.338
L- Great Toe	8.1	2.4	16.0	4.4	8.3	1.8	12.0	3.0	0.681
L- 1st Metatarsal Head	8.0	2.4	16.0	4.7	8.2	1.9	12.0	3.0	0.682

L- 3rd Metatarsal Head	7.9	2.4	16.0	5.0	8.3	1.9	12.0	3.0	0.348
L- 5th Metatarsal Head	8.0	2.5	16.0	4.0	8.3	2.0	12.0	3.0	0.539
L-Mid Arch	7.9	2.3	16.0	5.0	8.5	2.0	12.0	3.0	0.234
L- Heel	7.8	2.1	16.0	5.0	8.4	2.0	12.0	3.0	0.216
L- Dorsum	7.9	2.1	16.0	5.0	8.5	1.9	12.0	3.0	0.220
L- Ankle	8.2	2.5	16.0	5.0	8.5	2.0	12.0	3.0	0.527

P value significant at < 0.05

DISCUSSION

This study presents a comprehensive profile of the participants based on demographic, physiological, and health history data, alongside the results from sensitometer measurements. The findings reflect a young population with a relatively normal weight and height distribution, which is essential for contextualizing health outcomes and sensory perception evaluations.

Demographic and Physiological Findings

With a mean age of 21.59 years, the participants fall within a typical range for university students or young adults, a demographic that often presents different health challenges and characteristics compared to older populations [15,16]. The gender distribution reveals a notable female majority (45 females to 35 males), which may influence the overall results, particularly in studies related to sensory perception and pain thresholds, as research indicates gender differences in these parameters [17,18].

The average height (163.6 cm) and weight (58.48 kg) suggest a generally healthy population, with a Body Mass Index (BMI) of 21.82 kg/m², placing most participants within the normal weight classification [19].

These physical attributes (height, weight) warrant further investigation as they can influence sensory function, potentially interacting with factors like muscle mass and body fat distribution [20]. Notably, males exhibited significantly greater height and weight than females, consistent with established biological differences in skeletal structure and muscle mass [21]. These differences in age, height, and weight should be considered when analyzing sensory data, as they may introduce potential confounders. Previous studies have demonstrated significant gender variations in foot structure, which can influence gait and stability [22]. But in our study, despite potential confounding factors such as age and BMI differences between males and females, no significant differences were observed in VPT measurements.

Family History Implications

The family history data reveal that a significant number of participants (28 individuals) reported no history of diabetes or hypertension, indicating a potentially lower risk profile for these conditions within this cohort. However, the presence of family histories of diabetes (8 participants) and hypertension (21 participants) suggests a need for ongoing monitoring, given that these conditions have well-documented genetic components that can influence health outcomes over time [23,24]. The 23 participants with both conditions represent a critical subgroup warranting closer observation and possible early intervention strategies to mitigate the risk of developing these chronic diseases [25].

Sensitometer Measurements

The sensitometer measurements indicate varying sensitivity across different anatomical locations on the right and left sides of the body. Although mean readings for the right side slightly exceeded those for the left in several measurements, none of the differences reached statistical significance ($p > 0.05$). This may be due to the fact that most individuals are right-handed; they might have slightly greater sensory acuity or neural processing in the right side due to greater use and neural plasticity associated with the dominant hand. Also, the brain exhibits some degree of lateralization, with certain functions, including sensory processing, often being more dominant in one hemisphere. While the extent varies, a slight right-side dominance in sensory processing could contribute to the observed difference. The lack of significance suggests that while some variability exists in sensitivity, it is unlikely to represent a consistent physiological disparity [26, 27]. The range for VPT values were found to be 4.97-12.98 volts (2.5th - 97.5th percentile).

Such results align with previous studies that have reported individual variability in sensory perception without clear lateral dominance or consistent differences based on hand or foot sides [28]. Although the GT measurement exhibited the largest difference (8.43 for right vs. 8.17 for left), the p-value of 0.12 indicates that this difference could be statistically attributed to sample variability rather than true physiological variance [29].

Further investigation into the clinical implications of sensitometer results could be beneficial. For instance, while the average scores for sensitivity may not differ significantly, the range of results might reveal important insights into individual sensory processing capabilities. Identification of outliers could provide additional context regarding conditions that may impact sensory perception [30].

CONCLUSION

The findings of this study highlights the importance of considering demographic and health history factors when interpreting sensitometer measurements. While the default measures do not show significant lateral differences, a nuanced understanding of the sample characteristics enhances the interpretation of sensory data. Future research could investigate the correlations between family history, physical characteristics, and sensory perception to build a more integrated understanding of these interactions.

Limitations

This study has limitations, including a small sample size (80 participants), limiting generalizability, and a cross-sectional design that fails to capture sensory changes over time. Self-reported family history may introduce bias, and confounding factors like stress and socioeconomic status were unaccounted for. Sensitometer measurements were limited to specific body areas, lacking a comprehensive sensory assessment. Future research should address these issues to better understand demographics, health history, and sensory perception.

Future Scope

Future research should involve larger, diverse populations to improve generalizability and use longitudinal designs to track sensory changes over time. Comprehensive sensory assessments and studies on genetic markers could clarify links between genetics and sensory perception. Interventional studies on lifestyle modifications may identify strategies to reduce health risks. Additionally, exploring the impact of mental health on sensory processing could offer a more integrated understanding of physical and psychological well-being.

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