Masthead Logo

University of Iowa
Iowa Research Online

Proceedings of the Third American Conference on Human Vibration

6-2-2010

# Towards a Quantitative Sensory Test For Hand Numbness

A. J. Brammer
*University of Connecticut Health Center and Envir-O-Health Solutions, Ottawa*

M. G. Cherniack
*University of Connecticut Health Center*

E. Toppila
*Finnish Institute of Occupational health, Helsinki and Tampere University Hospital, Tampere*

***Please see article for additional authors.***

**DOI:** https://doi.org/10.17077/achv2010.1011

# TOWARDS A QUANTITATIVE SENSORY TEST FOR HAND NUMBNESS

***A.J. Brammer[1,2], M.G. Cherniack[1], E. Toppila[3,4], P. Sutinen[5], R. Lundström[6], T. Nilsson[7], G. Neely[8], T. Morse[1], A. Sinha[1], M.J. Eaman[2], D. Peterson[1], & N. Warren[1]**
**[1]Ergonomic Technology Center, University of Connecticut Health Center, Farmington, CT USA; [2]Envir-O-Health Solutions, Ottawa, ON Canada; [3]Finnish Institute of Occupational Health, Helsinki, Finland; [4]Department of Otolaryngology, Tampere University Hospital, Tampere, Finland; [5]Department of Physical Medicine and Rehabilitation, North Karelia Central Hospital, Joensuu, Finland; [6]Department of Biomedical Engineering and Informatics, University Hospital, Umeå, Sweden; [7]Department of Occupational and Environmental Medicine, Sundsvall Hospital, Sundsvall, Sweden, and; [8]Department of Psychology, Umeå University, Umeå, Sweden**

## Introduction

Sensory tests have long been used in clinical medicine for investigating peripheral neuropathies. The tests were originally primitive – pin prick (for pain), hot/cold objects (for temperature sense), and a cotton wool swab (for fine touch) applied to the skin. In this paper, a recently developed quantitative sensory test (QST) designed to confirm the presence or absence of numbness in the hands has been applied to a population of male forest workers (N=59, mean age 48.7 years, range 37-59), in which the prevalence of numbness reported by the workers was 29%. The test is based on measuring vibrotactile perception thresholds at the fingertips according to the provisions of ISO 13091-1. Under these measurement conditions, responses at specified stimulus frequencies are mediated by the slowly adapting, type I (*SAI*), and fast adapting type I (*FAI*), mechanoreceptors.[2] The metric is constructed from the differences between the thresholds recorded at the fingertip of an individual and the mean values of the thresholds for healthy persons obtained in other studies. In this paper, the performance of the QST is evaluated by adjusting a "fence" value for the metric to detect the onset of numbness.[2]

## Methods

When all thresholds are expressed as accelerations in units of dB (re $10^{-6}$ m.s$^{-2}$), the summed normalized threshold shift can be written, for each digit,[2] as:

$$TS_{Sum(SD)} = (TS_4 / SD_4) + (TS_{32} / SD_{32}) \qquad (1)$$

The shift in threshold at a stimulus frequency of 4 or 32 Hz, i.e., $TS_4$ or $TS_{32}$, represents the response of the SAI or FAI receptors, respectively, and is given by the difference between the observed threshold and the mean threshold recorded from the hands of healthy persons at that frequency. As the thresholds of healthy persons appear to approximate Gaussian distributions at each stimulus frequency, the ranges are expressed by standard deviations, $SD_4$ and $SD_{32}$, which are used to normalize the threshold shifts. In order to compare values of $TS_{Sum(SD)}$ with symptoms, the metric is taken to be the largest of the threshold shifts recorded from digit 3 or 5, in either hand.

Tests for the statistical significance of an association between the symptoms reported by individuals and values of $TS_{Sum(SD)}$ recorded from their hands have been conducted (Chi-squared test, and Fisher's exact test).[1] For this purpose, 2x2 contingency tables are formed to segregate the reported presence or absence of numbness, and a fence value, $t$, is selected for $TS_{Sum(SD)}$ to correspond to the boundary between the presence and absence of the symptom. The corresponding sensitivity and specificity is also evaluated.[1]

## Results and Discussion

The sensitivity and specificity of, and association between, the metric constructed from values of $TS_{Sum(SD)}$ recorded from each subject and their reports of numbness in the hands are shown in Table 1. The statistical significance of the association ($p$-value) is shown for different fence values, $t$. While the statistical tests differ somewhat in the fence values associated with numbness, values of $4.5 < t < 4.75$ are most significant, with probability values reaching $p < 0.005$. For these fence values, the sensitivity ranges from 50 to 43.75%, and the specificity from 87.5 to 92.5%.

Table 1: Sensitivity, Specificity and Tests of Association for Reports of Hand Numbness

| Fence $t$ | Sensitivity (%) | Specificity (%) | Yates $p$-value | Fisher $p$-value |
|---|---|---|---|---|
| 2.00 | 87.50 | 12.50 | 0.65 | 1.00 |
| 2.25 | 87.50 | 32.50 | 0.23 | 0.19 |
| 2.50 | 81.25 | 35.00 | 0.38 | 0.34 |
| 2.75 | 81.25 | 40.00 | 0.23 | 0.21 |
| 3.00 | 81.25 | 45.00 | 0.13 | 0.08 |
| 3.25 | 75.00 | 50.00 | 0.16 | 0.14 |
| 3.50 | 75.00 | 57.50 | 0.06 | 0.04 |
| 3.75 | 68.75 | 57.50 | 0.14 | 0.14 |
| 4.00 | 56.25 | 67.50 | 0.18 | 0.13 |
| 4.25 | 50.00 | 75.00 | 0.14 | 0.11 |
| 4.50 | 50.00 | 87.50 | 0.008 | 0.005 |
| 4.75 | 43.75 | 92.50 | 0.005 | 0.003 |
| 5.00 | 37.50 | 92.50 | 0.02 | 0.01 |
| 5.25 | 25.00 | 95.00 | 0.09 | 0.05 |
| 5.50 | 25.00 | 97.50 | 0.03 | 0.02 |
| 5.75 | 18.75 | 97.50 | 0.12 | 0.07 |
| 6.00 | 12.50 | 97.50 | 0.40 | 0.19 |
| 6.25 | 6.25 | 97.50 | 0.91 | 0.49 |

In a previous pilot study involving fifteen vibration-exposed workers, in which the prevalence of numbness was 39%, the statistically significant fence values for reports of numbness ranged from $3.3 < t < 4.4$, but the significance of the association never exceeded $p < 0.02$.[2] The sensitivity was, however, higher (~90%) and the specificity lower (~75%). The pilot study employed the same procedure for measuring vibrotactile thresholds as in this study, but combined values at two stimulation frequencies for each receptor type. Only one threshold per receptor type was obtained in the present study. This, combined with the lower prevalence of symptoms, may explain the differences in the results, but the potential for improving the metric remains to be explored. This would seem possible, as the correlation between threshold shifts in different receptor types within the same finger was much lower in this study (0.49-0.71 versus 0.87-0.97). Nevertheless, the low false positive rate (~10%) and a ~50% rate of confirmation of reported symptoms confirm the potential of mechanoreceptor-specific vibrotactile perception thresholds as a QST for numbness in the hands.

## References

1. Altman, D.G. (1991). *Practical Statistics for Medical Research*. London, Chapman & Hall.

2. Brammer, A.J., Sutinen, P., Das, S., Pyykkö, I., Toppila, E., Starck, J. (2010). Quantitative test for sensory hand symptoms based on mechanoreceptor-specific vibrotactile thresholds. J. Acoust. Soc. Am. **127**, 1146-1155.

(*Work supported by NIOSH grant U01 OH 071312*)