Comparison between multifrequency vibrometry, neurothesiometer and nerve conduction studies in subjects with type 1 diabetes.

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Aim

To compare the two methods (Multifrequency vibrometry and Neurothesiometer) for detection of vibration perception thresholds with nerve conduction studies.

Background

Nerve conduction studies (NCS) are considered as a gold standard for assessment of neuropathy. However, NCS is expensive and time consuming with limited access. Multifrequency vibrometry (MFV) is a new method for assessment of diabetic neuropathy. Impaired vibration perception thresholds (VPTs) at low frequencies (4 or 8 Hz) have shown to be associated with risk of diabetic foot ulceration and neuropathic symptoms, such as difficulties of gait and balance. Whether MFV and NCS correlates is unknown. Our aim was to compare two methods, Multifrequency Vibrometry and Neurothesiometer (NT) with nerve conduction studies.

Participants and Methods

Totally 51 patients (30 male, 21 female; age 51.6±13.6 years) with type 1 diabetes (T1DM) were investigated. VPTs were measured at seven frequencies (4, 8, 16, 32, 64, 125 and 250 Hz) in the sole of the foot - at the first (MTH1) and fifth metatarsal heads (MTH5). Neurothesiometer using 100 Hz frequency was measured twice at the bony prominent of MTH1 and a mean of the two measurement values was calculated. After that, a standard electrophysiological assessment was performed. In statistical analysis each foot was considered as separate measurements. Spearman rank correlation coefficient (r_s) was calculated for sensory nerve action potential amplitudes (SNAP) and velocities.

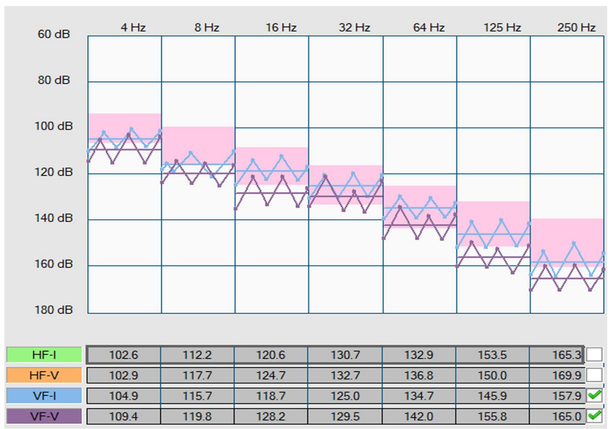

Figure1. Vibrogram. The pink area is normal range defined as mean ± 1.6xSD adjusted for age and sex. Blue line: left MT1, purple line: left MT5. (lines for right foot not shown). Numbers below are the VPTs for each frequency.

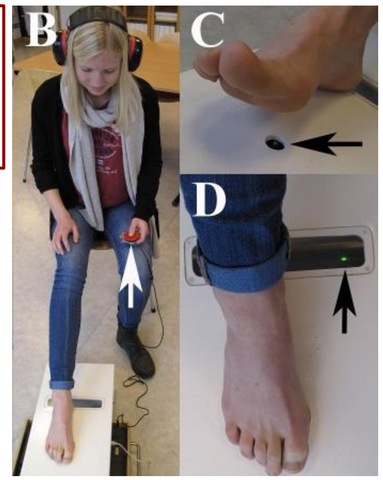

Figure 2. The experimental set-up:
The subject is sitting with the leg and foot in a relaxed position (B). The investigated area (head of the first or fifth metatarsal bone) is placed on a vibrating probe protruding from a circular surround (C). The probe pressure is adjusted before start of the test, to get a pre-defined force on the skin at the investigated area, which is indicated by a green light (D). During the test the subject responds by pressing or releasing a response button attached to the device (arrow) (B) when a vibration is, or is not, perceived. The intensity of the vibration increases when the response button is released and decreases when the button is pressed. The result registers as a vibrogram (see right).
The person on the photo is ***not*** one of the subjects in the study.
Photo from Dahlin et. Al. Vibrotactile perception in finger pulps and in the sole of the foot in healthy subjects among children or adolescents.
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Results

Table 1. Correlation matrix between Neurothesiometer (NT) and Multi Frequency VPTs vs electroneurograhy

	Peron. velocity	PN1 amplitude	PN2 amplitude	Tib. velocity	TB1 amplitude	TB2 amplitude	Sural velocity	Sural amplitude	NT
NT	-0.39	-0.39	-0.37	-0.34	-0.45	-0.47	-0.37	-0.61	-
MTH1 4 Hz	-0.55	-0.48	-0.45	-0.50	-0.51	-0.44	-0.53	-0.60	0.57
MTH1 8 Hz	-0.60	-0.56	-0.53	-0.55	-0.60	-0.54	-0.61	-0.69	0.58
MTH1 16 Hz	-0.60	-0.56	-0.52	-0.52	-0.58	-0.52	-0.61	-0.67	0.62
MTH1 32 Hz	-0.53	-0.53	-0.50	-0.48	-0.56	-0.53	-0.57	-0.68	0.68
MTH1 64 Hz	-0.58	-0.61	-0.58	-0.57	-0.65	-0.62	-0.63	-0.73	0.76
MTH1 125 Hz	-0.62	-0.67	-0.65	-0.63	-0.72	-0.69	-0.71	-0.81	0.74
MTH1 250 Hz	-0.59	-0.62	-0.61	-0.60	-0.65	-0.62	-0.64	-0.73	0.58
MTH5 4 Hz	-0.53	-0.54	-0.51	-0.50	-0.54	-0.47	-0.50	-0.62	0.51
MTH5 8 Hz	-0.58	-0.58	-0.56	-0.53	-0.58	-0.58	-0.56	-0.62	0.50
MTH5 16 Hz	-0.58	-0.59	-0.56	-0.57	-0.57	-0.55	-0.58	-0.66	0.55
MTH5 32 Hz	-0.58	-0.62	-0.59	-0.55	-0.61	-0.56	-0.57	-0.68	0.59
MTH5 64 Hz	-0.55	-0.62	-0.58	-0.53	-0.65	-0.61	-0.63	-0.76	0.70
MTH5 125 Hz	-0.57	-0.58	-0.55	-0.48	-0.65	-0.63	-0.63	-0.74	0.72
MTH5 250 Hz	-0.49	-0.51	-0.49	-0.45	-0.62	-0.60	-0.60	-0.71	0.66

NT= Neurothesiometer, PN1 peroneal nerve, stimulating electrode above fibular head, PN2 peroneal nerve, stimulating electrode at the ankle, TB1 tibial nerve, stimulating electrode at behind the knee, TB2 Tibial nerve stimulating electrode behind medial malleolus
P<0.0001 for all.

To calculate optimal cut-off for VPT_{125} vs. low sural SNAP, a ROC analysis was performed. Since vibration thresholds are dependent on age and gender, a z-score was calculated ($z = (x - \mu) / \sigma$, where x=value, x=age and gender specific mean and σ =standard deviation). When choosing a z-score for 125 Hz threshold of 0.99 (optimal Youden index), sensitivity was 69.4%, specificity was 74.4% with the Youden index 0.44 and AUC 0.79, p= 0.000001.

Table 2. Increased VPT at MT1 (125 Hz) vs. pathological sural SNAP.

	VPT_{125}	
Sural Amplitude	Normal	High
Normal	32 (34.8%)	11 (12.0%)
Low	15 (16.3%)	34 (37%)

High VPT corresponds z-score ≥ 1.0.
Numbers are number of measurements (% of total)

Conclusions

- Best correlation between sural SNAP and VPT_{125Hz} is measured at the MTH1.
- Impairment in VPTs reflects mainly a decline in nerve fibre density?
- Having VPT_{125Hz} > mean+SD can be considered as early sign of subclinical neuropathy.
- Multifrequency vibrometry is a non-invasive method that can be used instead of NCS for early assessment of diabetic neuropathy in T1DM.

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