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Temperature and vibration thresholds in vibration syndrome

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ABSTRACT In a study to investigate whether the quantitative assessment of temperature and vibration thresholds can improve the evaluation of the neurological symptoms in vibration syndrome 37 patients with neurological symptoms (paraesthesias, numbness, pain) in the hands who had worked with hand held vibrating tools and 46 healthy controls not exposed to vibration were examined. Temperature thresholds were measured on the thenar eminence and on the volar side of the second and third fingers held together. Vibration thresholds were determined on the dorsum of the hand and on the dorsal side of the second and fifth fingers proximal to the nail. The neutral zone between thresholds for warmth and cold was much wider in the patients than in the controls. Patients older than 45 had higher vibration thresholds than controls. Electroneurography was abnormal in 18 of 34 patients and a carpal tunnel syndrome was diagnosed in six subjects. This investigation is thus indicated in patients with neurological symptoms. Seven of the patients with normal electroneurographic findings had impaired temperature or vibration thresholds or both. Determination of sensory thresholds seems to add valuable information and the methods are, by contrast with electroneurography, easily adapted to the screening of exposed groups outside hospital. Our results indicate that thin myelinated and unmyelinated nerve fibres might be damaged in the vibration syndrome.

Workers exposed to vibration often complain of paraesthesias in their hands,[1] and work with vibrating tools may cause damage to the peripheral nerves as well as symptoms from the blood vessels of the fingers. Many lumberjacks using vibrating chain saws have peripheral neuropathy with decreased motor nerve conduction velocities in their hands.[2] Carpal tunnel syndrome is more common in workers exposed to vibration than in controls, and latency, duration, and amplitude of sensory action potentials differ between such subjects and controls.[3] Follow up studies indicate that paraesthesias and numbness in the hands and arms cause subjective disability more often than Raynaud's phenomenon[4] and that these symptoms also may be persistent when exposure to vibration decreases.[4 5] Thus neurological disturbances should be objectively verified as soon as possible. The aim of the present study was to determine whether quantitative measurement of vibration and temperature thresholds, as a complement to electroneurography, can be of diagnostic help in the objective assessment of the neurological symptoms in the vibration syndrome.

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Subjects and methods

All patients referred to the Department of Occupational Medicine, Södersjukhuset, in 1983 because of suspected vibration syndrome were interviewed. Those who had neurological symptoms in the form of paraesthesias, numbness or pain, or both, in their hands were included in the study.

Patients with exposure to neurotoxic chemicals such as solvents, or with diseases associated with neuropathy (diabetes, for example) were excluded from the study. We examined 37 men aged 24 to 66 (mean 47, SD 10·5). Forty six healthy men aged 24 to 65 (mean 43, SD 10·3) who had never worked with vibrating tools or with neurotoxic chemicals were used as controls for the temperature and vibration threshold measurements.

The temperature and vibration thresholds were measured in the morning at least 16 hours after exposure to vibrating tools to avoid a possible

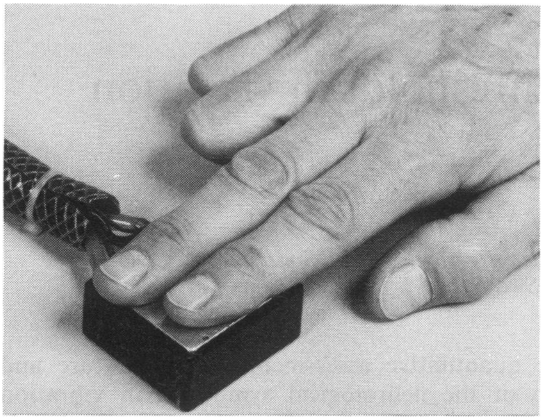

Fig 1 *Measurement of temperature thresholds in dig II + III.*

Fig 3 *Measurement of vibration threshold.*

influence from the temporary vibration threshold shift found in the finger tips after acute exposure.[6 7] As skin temperature may influence sensory thresholds[8 9] the hands were warmed if the finger temperature was less than 32°C. The presence or absence of Raynaud's phenomenon was noted.

Temperature thresholds for warm and cold sensations were determined by the "Marstock" method.[10] A Peltier element controlled the temperature of a thin metal plate in contact with the skin. The size of the plate was 35 mm × 40 mm, and its temperature was measured with a thermistor located in the middle of the plate and registered on a pen recorder. The rate of temperature change was 1°C/s. After measuring the skin temperature with a thermocouple (Ellab DU-3), the probe was applied first to the skin of the thenar eminence and then to the distal volar aspect of the second and third fingers (fig 1). The subject pressed a switch whenever he experienced a warm or a cold sensation. This produced a reversed current flow through the Peltier element that altered the direction of temperature change. The temperature thus oscillated between the thresholds for warmth and cold. When the recording had stabilised, the neutral zone was read as the distance between warm peaks and cold troughs (fig 2).

Vibration thresholds were determined according to Goldberg and Lindblom.[11] A hand held vibrator (Vibrameter, Somedic AB) with a 13 mm diameter plastic probe and a stimulus frequency of 100 Hz was placed in contact with the skin above the dorsal aspect of the second metacarpal and dorsally on the second and fifth digits just proximal to the nail root (fig 3). The static pressure on the skin was determined by the weight of the vibrator (500 g). The probe dis-

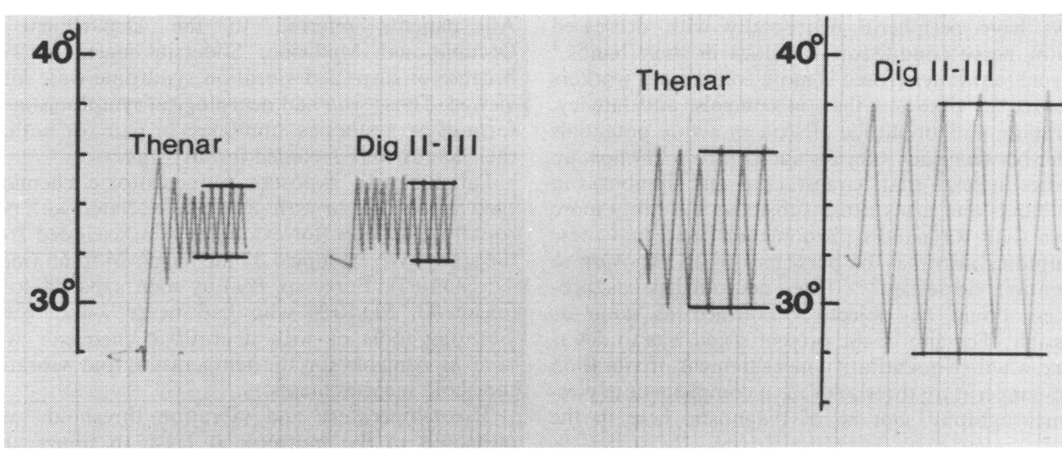

Fig 2 *Recordings of temperature thresholds in control subject (left) and patient (right).*

placement was measured by an optic device built into the vibrator, and the result was shown on a digital display. The amplitude of the vibration was slowly increased until it was perceived by the subject and then slowly decreased until it was not experienced. This was repeated twice and the threshold was defined as the mean of these measurements.

Thirty four of the 37 patients were examined with electroneurography (ENeG). Motor and sensory conduction velocities and amplitudes of sensory action potentials were determined in the median and ulnar nerves on both sides.

For the establishment of an upper limit of normal the method of tolerance limits with confidence was used.[12] A confidence level of 99% was chosen, and the upper normal limit was set to include 97·5% of a healthy population. For comparison between the groups, a *t* test was used (two sided p values).

Results

TEMPERATURE THRESHOLDS

Figure 4 shows the neutral zones of the patients and controls. The patients had significantly wider neutral zones than the controls at all areas examined. One control and 20 patients had one or more values outside the normal limits suggested in table 1. There was no correlation with age. Both groups had significantly higher thresholds in the right than in the left hand. Patients having Raynaud's phenomenon did not differ significantly from patients without white finger. Thresholds for heat and cold are shown in fig 5; cold thresholds discriminated cases from controls better than heat thresholds.

VIBRATION THRESHOLDS

The vibration thresholds of the controls are shown in table 2 with suggested upper normal limits. The thresholds in the right hand of the patients are shown in fig 6; the thresholds were similar in the left hand. Three controls and 13 patients had one or more values outside the normal limits. The patients had significantly higher thresholds than the controls ($p < 0·01$). When the subjects were divided into two groups (age $\leqslant 45$ and > 45) the patients had higher thresholds only in the higher age group ($p < 0·05$). In the control group there was a significant correlation between age and threshold only in the second finger of the right hand whereas the thresholds increased significantly with age in the patient group at all examined points.

ELECTRONEUROGRAPHY

Sixteen patients had normal and 18 abnormal results. Eleven had abnormal results in the median nerve (six were considered to have carpal tunnel syndrome and were referred for surgery) and four in the ulnar nerve. Three had changes in both nerves.

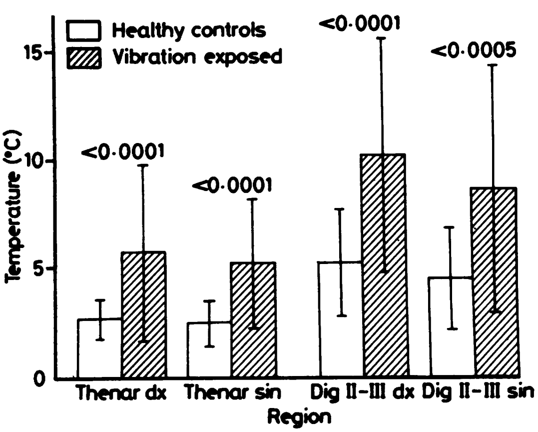

Fig 4 *Width of neutral zones in controls (□) and patients (▨). Means ± SD and p values are shown.*

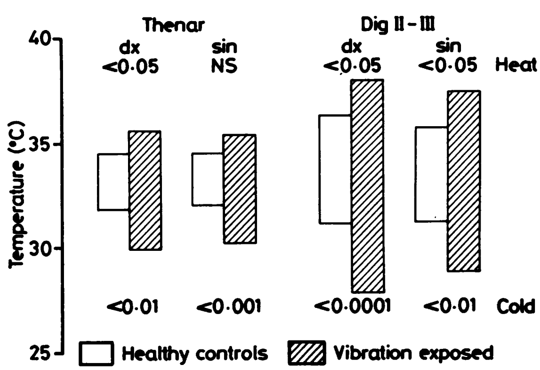

Fig 5 *Thresholds for heat and cold in controls (□) and patients (▨). Means and p values are shown.*

Table 1 *Neutral zones (°C) in 46 controls*

Examined area	*Mean*	*SD*	*Suggested upper normal limit*	*No outside normal limit*
Thenar dx	2·7	0·9	5·5	—
Thenar sin	2·5	1·0	5·5	—
Dig II-III dx	5·2	2·5	12	1
Dig II-III sin	4·5	2·3	11	—
				1 subject

Table 2 *Vibration thresholds (µm) in 46 controls, subdivided according to age (≤45 and >45)*

Examined area	*No*	*Mean*	*SD*	*Suggested upper normal limit*	*No outside normal limit*
Carp dx:				0·70	1
≤45	26	0·27	0·14		
>45	20	0·29	0·16		
Carp sin:				0·70	1
≤45	26	0·25	0·12		
>45	20	0·33	0·20		
Dig II dx:					
≤45	26	0·46	0·23	1·1	1
>45	20	0·64	0·29	1·7	—
Dig II sin:					
≤45	26	0·45	0·21	1·1	—
>45	20	0·57	0·35	1·7	—
Dig V dx:					
≤45	26	0·49	0·31	1·5	—
>45	20	0·63	0·29	1·6	—
Dig V sin:					
≤45	26	0·48	0·33	1·5	1
>45	20	0·53	0·23	1·6	—
					3 subjects

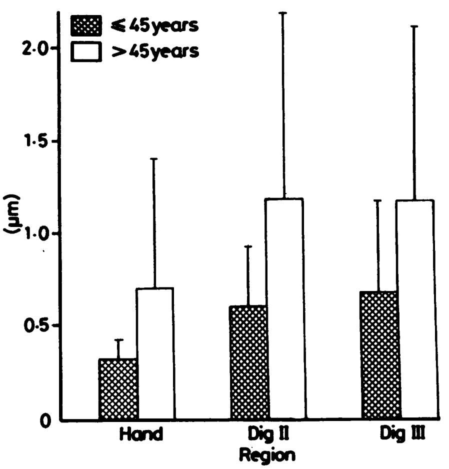

Fig 6 *Vibration thresholds of right hand in patients stratified with respect to age into two groups, 45 and under (▩, n = 15) or over 45 (□, n = 22).*

Of the 16 patients with normal electroneurography, four had abnormal vibration thresholds and six abnormal temperature thresholds. Altogether seven of the 16 patients with normal ENeG had disturbed sensory function with regard to vibration or temperature thresholds or both. Four patients with abnormal ENeG had sensory function within normal limits.

Discussion

A widening of the neutral zone for temperature sensation was the most common abnormality in our patient group and the difference from the control group was highly significant. The temperature receptors are supplied with thin myelinated and unmyelinated afferent nerve fibres,[13] and the results indicate that damage to these receptors or fibres is common in the vibration syndrome. Cold receptors are sensitive to reduced blood flow and hypoxia,[14] but since patients with and without Raynaud's phenomenon did not differ in temperature thresholds it does not seem probable that the nerve lesions are secondary to circulatory disturbances.

To date, little attention has been given to temperature sensitivity in the vibration syndrome. Clinical studies indicate an impaired temperature discrimination in some patients,[15] but minor sensory loss is difficult to evaluate with conventional clinical methods and is better assessed with quantitative techniques such as those used in the present study. Recent studies with another quantitative technique showed wide neutral zones in patients compared with controls.[16 17] and an impaired temperature sensitivity has been described as the only abnormal finding in two of 22 vibration exposed patients.[18]

It might be argued that differences in skin thickness contribute to the difference between groups in temperature thresholds, since the control group included white collar workers while all patients were manual workers. Further, both in the patient and control groups the right hand was slightly less sensitive than the left. This might be due to the dominant hand having thicker skin. Temperature thresholds, however, were higher in exposed workers with symptoms than in workers with no complaints from the same occupational categories.[17] Thus it seems probable that temperature discrimination is impaired in vibration syndrome and that this at least partly depends on exposure to vibration.

Abnormal vibration thresholds were less common than abnormal temperature thresholds in the patient group. Although all the patients had neurological symptoms, only those older than 45 differed significantly from the controls. In unselected lumberjacks no significant increase in vibration thresholds was found on the dorsal side of the fingers.[19] The vibration threshold was not significantly higher in exposed patients with neurological symptoms than in exposed controls, or manual worker controls when measured in the finger pulp.[6] Increased vibration thresholds on the volar side of the fingers have, however, been found in patients with vibration induced neuropathy[20] and in dentists[7] and physiotherapists exposed to ultrasonic devices.[21]

The weak correlation between age and vibration thresholds in the control group is in accordance with an earlier study.[11] The temperature thresholds on the palms of the controls are similar to those in an earlier study (H Fruhstorfer, personal communication). The neutral zones in the fingers of 31 male subjects without exposure to vibration were 1·4–2·1°C wider[17] than those of the controls in our study. This might be explained by the smaller area stimulated (middle finger tips compared to tips of dig II + III) and by the different technique used.

It is important to refer exposed workers with neurological symptoms in the arms and hands for a complete neurophysiological examination, since many have abnormal findings. The high frequency of carpal tunnel syndrome (six out of 34) is an indication for neurography in patients with neurological symptoms. Vibration and temperature thresholds are comparatively easy to measure quantitatively and may be used for screening surveys in exposed groups even outside hospital. Regular monitoring of sensory thresholds might be of value for the early identification of the vibration syndrome.

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