International Journal of Occupational Medicine and Environmental Health, Vol. 7, No 1, 77–85, 1994

MULTIFUNCTIONAL AESTHESIOMETER "TELMEST"[1]

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Key words: Aesthesiometer, Sensory stimuli, Vibration, Electric current, Temperature, Threshold perception

Abstract. A multifunctional device "TELMEST" has been developed for checking of actual temperature and for testing the perception threshold of electric current, mechanical vibration and temperature. The operational microprocessor system delivers appropriate stimuli by applicators to the finger tips or to other areas of skin, and the sensory responses of the proband are displayed on the screen of the monitor and stored in the memory. The estimation of tegumental temperature and perception thresholds of the above mentioned sensory stimuli supply valuable indices of sensory and vascular dysfunctions due to exposure to mechanical vibration transmitted to the hands. The results of such tests are exemplified.

INTRODUCTION

A qualitative estimation of tactile perception in finger tips and in other areas of skin has been applied in neurological disorders. Since the development and use of hand tools generating mechanical vibrations it has become evident that tactile perception test is useful in diagnosis of postvibrational impairment of the tactile sense. It has also become evident that there are common receptors for tactile and vibrational stimuli (14). By analogy to audiometric estimation of hearing ability several kinds of aesthesiometers have been designed for estimation tactile perception in finger tips and in glabrous skin of the hand (1, 9, 14). Since description in 1973 (5) of previous and existing at that time devices for estimation of tactile ability (palesthesiometers) further improvement of such devices has been made by our team (aesthesimeters MCW-2k, MCW-80) and by others (2, 4, 10, 11, 13).

[1] Supported by the Project CPBR 11.11.45.2 (1986/1989).

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The postvibrational pathological disorders involve damage of tactile receptors (mechanoreceptors), peripheral blood vessels and peripheral nerves. Such damages could be tested by checking of local actual temperature, and by perception thresholds of mechanical, thermal and electrical stimuli. For such purposes a multifunctional device has been developed allowing to estimate (EST) quantitatively actual temperature and perception threshold of temperature (T), electric current (EL) and mechanical (M) stimuli. The akronymes marked in parantheses make thus the name "TELMEST" of the device (manufactured in the Medical Engineering Unit, Lodz, Poland).

FUNCTIONAL CHARACTERISTICS OF TELMEST

TELMEST includes: 1) Operational system in the central consola containing microcomputer, power supply and separatory transformer. 2) Set of applicators for link with central consola outputs of stimuli and imputs of responses. 3) Set for link of the operator with operational system i.e. video display unit, keyboard, and printer (Fig. 1).

Actual temperature of the skin is measured with the thermistor sensor within $20-40\pm0.2°C$. The applicators of specific stimuli include: a) Heat applicator in the form of cuboidal blocks of brass maintaining constant temperature of 35, 40, 50 and 55°C with accuracy $\pm0.1°C$, b) Disc, needle or spherical electrodes of diameter 1.5 or 5 mm for application of direct current (DC) increasing by 33 μA/s within the range 0−2 mA, of alternating current (AC) of 50, 100, 200, 400 and 1000 Hz increasing by 33 μA/s within 0−2 mA, and of transient current derived from capacitor discharge within the range 0−2 mA, c) Stationary and movable appli-

Fig. 1. TELMEST: 1) Main console containing computer and decisive module systems. 2) Video display unit with keyboard. 3) Printer. 4) Movable applicator of vibration. 5) Thermistor probe of actual temperature. 6) Applicator of constant temperature stimuli. 7) Applicators of current stimuli. 8) Switch for proband's of stimulus perception.

cators of sinusoidal vibration of 32, 63, 125, 162, 192, 250, 400, 500 and 640 Hz within the range of velocity amplitude 0.05 – 50 mm/s or 60 – 110 dB re 5.10^{-8} m/s. The stationary applicator is designed for estimation of vibration perception thresholds in the finger tips and movable applicator owing to articulated extension arm is used for estimation of vibration perception thresholds in a desired area of the human body.

The actual temperature of the skin is the objective descriptor and other descriptors are quantitated by subjective perception of applied stimuli. Kinds and intensities of applied stimuli are continuously displayed on the VDU screen and their final intensities denoting the threshold sensation are introduced automatically into computer memory after pressing a signal button by person being investigated (proband).

The operational program is of conversational type and an operator can stop the program any time it is needed, to repeat some steps, to introduce desired changes or additional data. After completion of investigation all data could be displayed on the monitor and printed. Additional output from the central consola makes possible the programmable storage and computation of a large amount of data by external computer.

INVESTIGATION PRINCIPLES WITH TELEMEST

The investigation with TELMEST should be performed in standard conditions: quiet room with background noise about 50 dB(A) and without noise coming from outside; indoor air temperature 22 ± 2°C; relative humidity about 60%; the person to be investigated is requested not to smoke at least 30 minutes before investigation. At the beginning of investigation the proband is informed about the procedure of investigation and the kind of sensation he/she may expect after application of particular stimuli. Some introductory test with stimuli are also appreciated. The sequence of tests is recommended as follows.

1. Checking of actual temperature of the skin in finger tips and in the predetermined points in the glabrous skin of hands and in the skin of the forearms.
2. Estimation of the threshold perception of temperature in finger tips: the proband touches the surface of cuboid applicator of heat with a tip of particular fingers and reports its sensation. When the actual temperature in finger tips and the skin of hands is below 25°C it is necessary to warm hands of the proband with radiators like infrared lamp, electric heater or central heating radiator, and after elevation of the skin temperature to 25°C or higher tests could be performed.
3. Estimation of the threshold perception of mechanical vibration applied from a stationary applicator to the finger tips or from a movable applicator to any other region of the body: the proband reports the threshold perception for each of applied frequencies.
4. Estimation of the threshold perception of direct, alternate and transient currents applied from spherical applicator to any area of the skin with neutral electrode attached to the similar area of the skin. The proband reports the first clear sensation of current (tingling, vibration, pinching).

All the test of the investigation program in 21 areas of hands and forearms (Fig. 2) take 45 – 60 minutes. However, it is possible to perform these tests in selected

areas e.g. in the finger tips or in the glabrous skin of the hands. Such limited program of investigation is completed within 10–15 minutes.

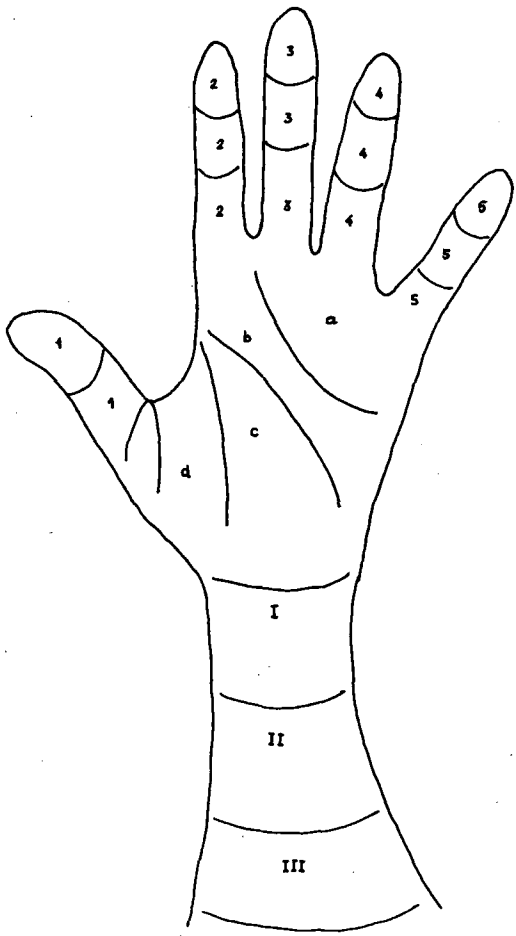

Fig. 2. Anatomical areas of the finger, hand and forearm for testing the actual temperature perception of vibration and current.

The most important problem is the presentation of results of the investigation. A physician is satisfied with such a presentation of results that makes possible a quick distinction between normal and pathological values of data. Such presentation is possible for a limited number of data what is illustrated by examples described below. An easy and legible presentation of larger number of data requires special computational and graphic programs. Actually the physician is supplied with all printed results and with graphic presentation of data limited to selected stimuli applied to finger tips.

RESULTS OF INVESTIGATION WITH TELMEST

Practitioners in the Outpatient Clinic at this Institute are familiar with the evaluation of average levels of vibration perception in finger tips as indicated in

Table 1. Test card – vibratory perception thresholds

Date of test _____
Proband name _____ Age _____
Occupation _____ Period (years) _____
Factory _____

Hz	Vibration perception threshold in finger tips (dB)*: right hand				left hand			
	II	III	IV	V	II	III	IV	V
63	78	78	78	78	78	78	78	78
125	70	70	70	70	70	70	70	70
250	72	72	72	72	72	72	72	72
400	74	76	76	76	76	76	76	76
500	78	80	80	80	79	78	78	78
640	82	82	82	84	81	80	80	80
800	84	84	85	88	82	82	82	82

*re 5×10^{-8} m/s

TELMEST

Testing instrument _____
Remarks _____

_____
examiner's signature

Table 1. Two ways of practical evaluation of the results of investigation with TELMEST are presented: a conventional one where the results of vibration perception in finger tips are printed on the averse side of the test card (Table 1) with calculation of the average level based on selected number of data as marked by rectangular area in Table 1. The other one where the reverse side of the test card illustrates the diagram of perception thresholds of 50 Hz current and of 250 Hz sinusoidal vibration, actual temperature and perception threshold of heat in the finger tips of the left and the right hand provides an easy and quick distinction between normal and abnormal values (Figs 3 and 4).

The pre-employment investigation reveals differences in actual temperature and in perception thresholds of applied stimuli. One male subject (P.W.) (Fig. 3) having relatively high actual temperature of the skin and normal perception thresholds in the finger tips will be allowed to work with vibrating hand tools. Another male subject (P.S.) (Fig. 3) having relatively low actual temperature of the skin and slightly elevated perception thresholds of current and vibration in the finger tips should be shifted to another job free from occupational exposure to hand transmitted vibration. After 8 to 22 years of occupational exposure (chain-sawyers, cleaners, polishers) (Figs 3 and 4) the perception thresholds of applied stimuli in the finger tips are abnormally high and actual temperature of the skin is relatively low. It could be

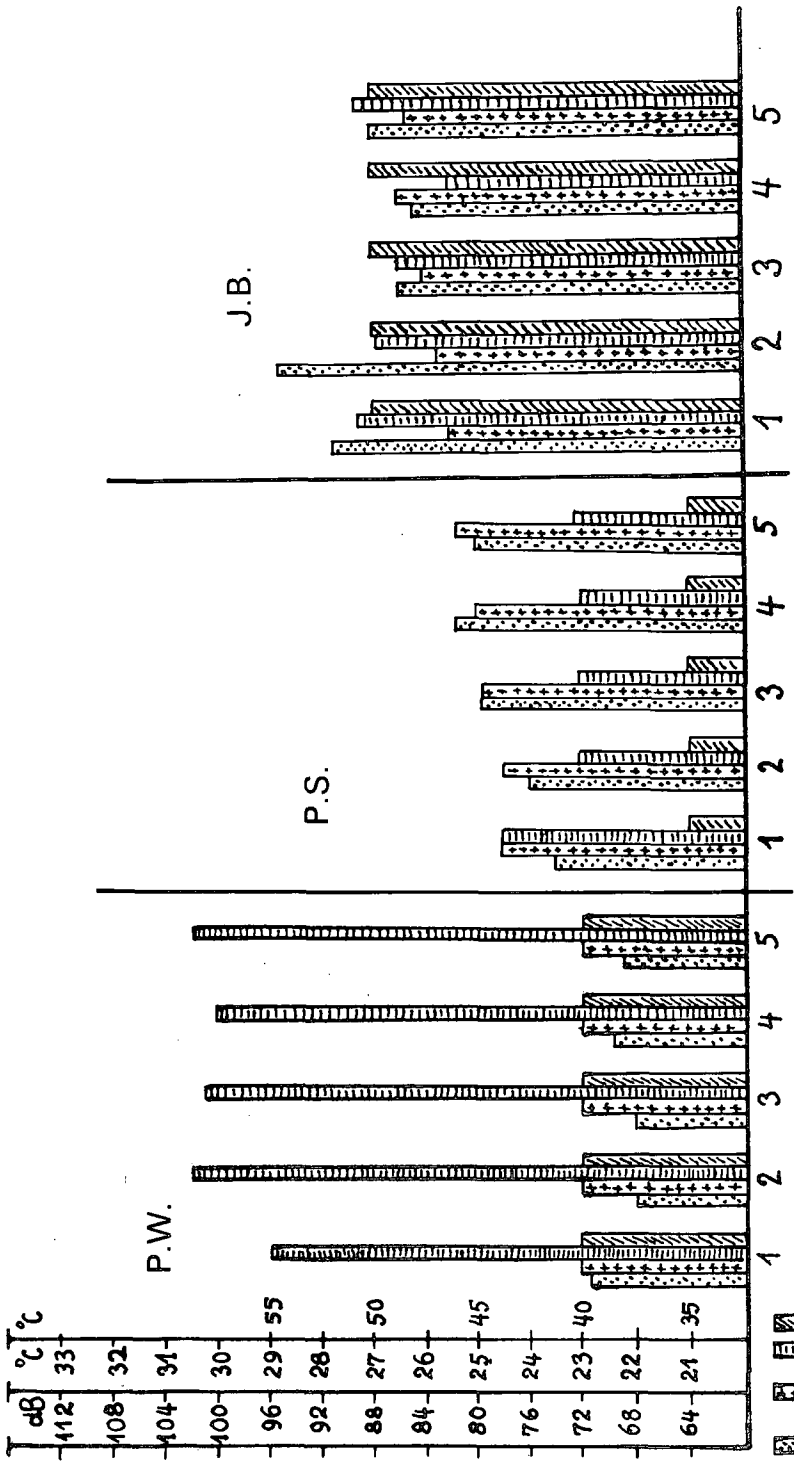

Fig. 3. Actual temperature (t_1) and perception thresholds of 50 Hz current (μA), 250 Hz vibration (dB) and heat (t_2) in finger tips of the right hand: P.W. – healthy man aged 22. P.S. – chain-sawyer aged 25 and after few months of employment: low values of actual temperature of the skin (t_1). J.B. – chain-sawyer aged 39 and after 8 years of employment: relatively low values of skin temperature (t_1) and moderately augmented perception values of current (μA), vibration (dB) and heat (t_2).

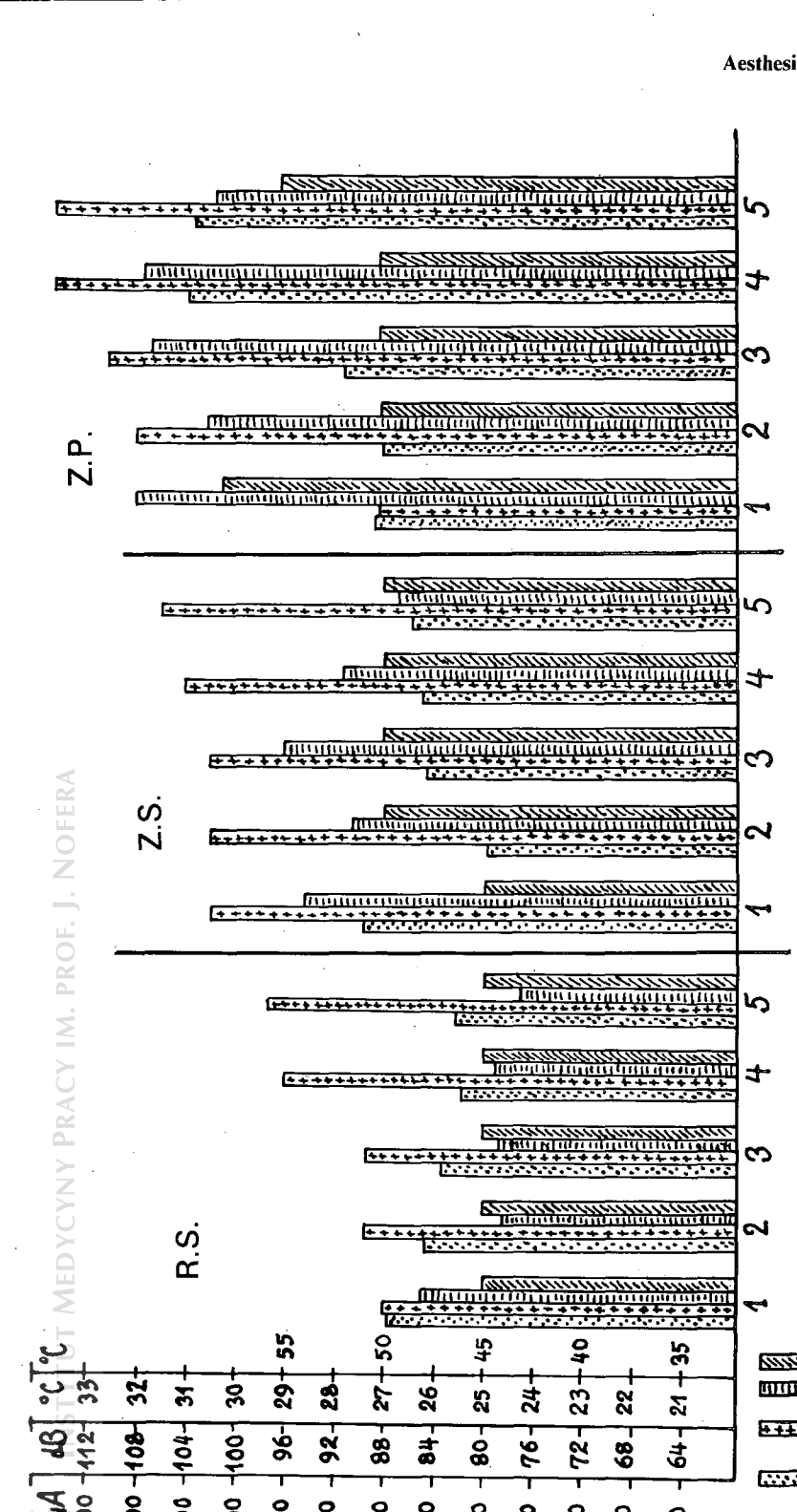

Fig. 4. Actual temperature (t_1) and perception thresholds of 50 Hz current (μA), 250 Hz vibration (dB) and heat (t_2) in finger tips of the right hand: R.S. – chain-sawyer aged 50 and after 22 years of employment: relatively low values of skin temperature (t_1) and moderately augmented perception values of current (μA) and vibration (dB). Z.S. – cleaner in foundry, aged 42 and after 12 years of employment: relatively low values of skin temperature (t_1) and significantly augmented perception values of current (μA), vibration (dB) and heat (t_2). Z.P. – cleaner in foundry, aged 51 and after 10 years of employment: quite normal skin temperature (t_1) and very significantly augmented perception values of current (μA), vibration (dB) and heat (t_2).

It could be expected that further exposure to vibrations exceeding permissible levels will lead to exacerbated postvibrational changes in those workers.

The above examples of pre-employment and periodic control tests with TELMEST in workers not yet or already exposed to hand transmitted vibration prove the prognostic and/or diagnostic usefullness of the perception tests for occupational health practitioners.

DISCUSSION

The intense short term or moderate long term exposure to the hand transmitted vibration induce functional and pathological changes in peripheral nerves, blood vessels, muscles and bones. An early detection of discussed postvibrational changes is highly desirable and allows to stop the exposure to damaging vibration. The vibratory perception test, plethysmography, and cooling test belong to useful methods for early detection of changes in fingers (2, 3, 4, 6, 7, 8, 11, 12, 15). TELMEST is the device which provides a better diagnosis of postvibrational changes. It is difficult to predict whether TELMEST will be able to ascertain the prevalence of vibratory perception over questions providing current perception test, temperature perception test or checking of actual temperature. Nevertheless, all the tests are well reproducible and give better insight into susceptibility to vibration and progress of already existing postvibrational symptoms. The application of current using probes of various sizes and shapes facilitates the investigation of receptors' distribution in the skin. TELMEST may be useful device for perception tests in physiological research and in the diagnosis of neurological disorders.

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Received for publication: April 30, 1993
Approved for publication: January 7, 1994