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The Qualitative Assesment of Emerging Risks to Workers Exposed to HAV

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Abstract: In this paper has been studied a group of 10 subjects who work in an environment where there is HAV. Their work experience varies from 5 to 42 years. Of these subjects, seven are smokers and three non-smokers. There were made two types of tests: the first refers to a r.m.s measurements depending on frequency and temperature, for both hands. The second is a medical questionnaire, administered by a physician, which holds the disease history of the subjects, the social factors, etc.. It was found that there is a strong dependence of the occurrence of occupational diseases (VWF) and a variety of factors.

Key words: HAV, palm sensitivity, $a_{r.m.s.}$, frequency, temperature.

Nomenclature

$a_{r.m.s.}$:	Root mean square acceleration (m/s^2)
T:	Temperature (°C)
VWF:	Vibration white finger
HAV:	Hand arm vibration

Greek Letter

v:	Frequency (Hz)

1. Introduction

The purpose of this paper is to analyse the vibrotactile capacity of the men who work in a vibrational environment.

The test was based on the study of a 10 workers group who work in a HAV environment. In this case the VWF syndrome may appear. However not only the vibrations induce this disease but a lot of other factors concur to its arise. It is understood that the vibrotactile capacity will be influenced by the vibrations' characteristics (frequency, intensity, amplitude, etc.), by the equipment used, by the time spent in the vibrational environment, by age and by the work experience, by the temperature of the environment, the social factors (if the subjects are smokers or not, if the drink alcohol) by the medical history, etc..

Transmission of vibration in hand is made via the somatosensory system, with its mechanoreceptors in the skin. There are four receptors located underneath the hand skin that react to mechanical action. These receptors are Merkel, Ruffini, Meissner and Pacini (Fig. 1) [1]. The properties of these receptors are presented in Table 1 [2].

Table 1 shows that through Merkel receptor, the overall feeling of touched object is felt. Through Ruffini receptor the mechanical tension is felt. The Meissner receptors are responsible for perception of the velocity of the skin deformation, used to control the strength or pressure with which a certain part of the skin touches a surface or grabs an object. The Pacini corpuscles are responsible for accelerations in the skin deformation with highest sensitivity at about 100-200 Hz and serve for the perception of roughness. All receptors contribute to the sensation of vibration perceived through the skin of the hand [3, 4].

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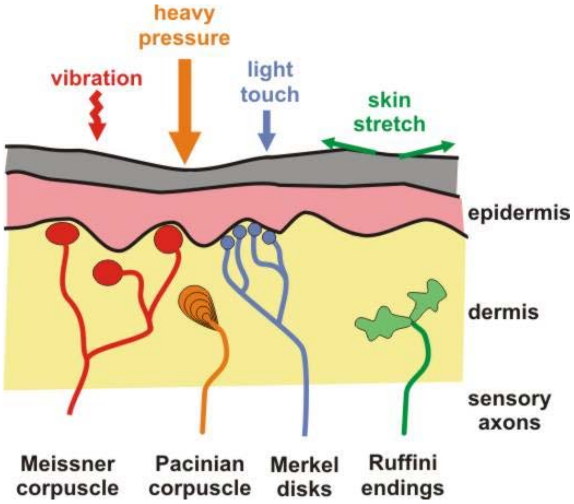

Fig. 1 The skin harbours a variety of morphologically distinct mechanoreceptors. This diagram represents the smooth, hairless (also called glabrous) skin of the fingertip.

2. Methods

In this paper has been studied a group of 10 subjects who work in an environment where there is HAV; their ages ranged from 28 to 60 years; their work experience varies from 5 to 42 years. Of these subjects, seven are smokers and three non-smokers.

2.1 Social Questionnaire

Contains the medical history, age, the social factors (if the subjects are smokers or not, if the drink alcohol), the VWF symptoms. These symptoms are quantified by a score for the 10 fingers (Fig. 2) [5, 6]. The total score is: (1 + 2 + 1 + 2 + 3 + 1 + 2 + 3 + 1 + 2 + 3 + 1 + 2 + 3) × 2 = 29 × 2 = 58 for both hands (Table 2).

2.2 Exposure Questionnaire:

Contains the history of the vibration exposure of the subject, the types of equipment which he uses, the time spent in a vibrational environment, his work experience [7].

2.3 The Temperature Measurement

The skin temperature is measured with thermocouples which are in good contact with the skin. Also, the room temperature is measured.

2.4 The Vibrations' Characteristics

The measurements were made using NetdB, Complex system for analysis and measurement of remitted vibration to human body with dBFA Suite, Software for acquisition command and data post-process and PCB Piezotronics triaxial piezoelectric accelerometers. Vibration magnitudes were expressed as root-mean-square acceleration, frequency-weighted using frequency weighting W_h in accord with ISO 5349/2001. In addition, unweighted acceleration magnitudes were obtained over the same nominal frequency range (4-125 Hz). The measurement time for every test set was 10 min. Working frequencies were 4, 16, 32, 63, 125Hz [8, 9].

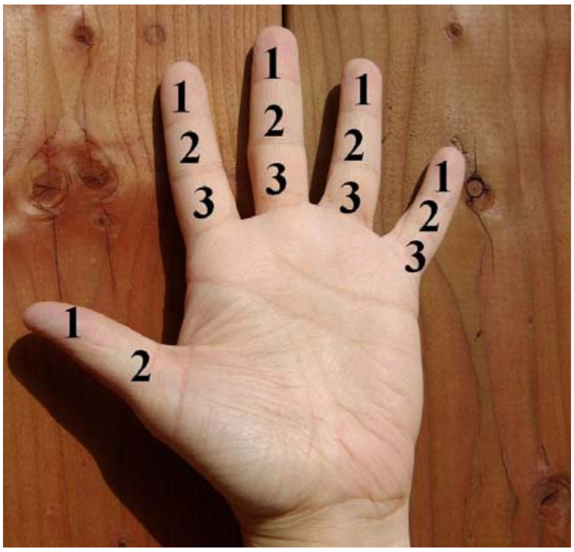

Fig. 2 Method to quantify the size perception for right and left hand fingers, where: first phalanx = 1 point; second phalanx = 2 points; third phalanx = 3 points.

Table 1 Mechanoreceptors in the human hand.

Receptor	Receptor Field/ Density	Cue
Merkel	2 mm/ ~ 100/cm^2	Skin Indention, Vibrations ~ 4 Hz
Ruffini	8 mm/ ~ 20/cm^2	Stretching
Meissner	5 mm/ ~ 150/cm^2	Velocity, Vibrations < ~ 80 Hz
Pacini	Palm/ Finger/ ~20/cm^2	Acceleration, Vibrations ~ 40 to 500 Hz

Table 2 Method to quantify the size perception for right and left hand fingers.

Perception	Right hand fingers				
	Thumb	Index	Middle	Ring	Little
Theoretical perception	1 + 2	1 + 2 + 3	1 + 2 + 3	1 + 2 + 3	1 + 2 + 3
Average of real perception for those 10 subjects	0	1	1 + 1	1	0
Ratio	4/29				

Perception	Left hand fingers				
	Thumb	Index	Middle	Ring	Little
Theoretical perception	1 + 2	1 + 2 + 3	1 + 2 + 3	1 + 2 + 3	1 + 2 + 3
Average of real perception for those 10 subjects	1	1 + 1	1 + 1	1 + 1 + 1	1 + 1 + 1
Ratio	11/29				

3. Results

Average of real perception for those 10 subjects was 4 for right hand fingers and 11 for left hand fingers. This means that the fingers on the subjects' right hand are less sensitive, especially due to the fact that all the subjects are right-handed. This is clearly shown in Figs. 3 and 4.

Table 3 shows that the perception on the right hand is higher than it is on the left, most cases with 25%. There are cases when this increase is much higher, for example:

- For the middle finger (4 Hz), the perception on the left hand is higher with 36.36%;
- For the ring finger (16 Hz), the perception on the left hand is higher with 55.55%;
- For the ring finger (32 Hz), the perception on the left hand is higher with 70.58%.

If Fig. 3 and 4 show the way the subjects perceive the accelerations in terms of frequency, Fig. 5 and 6 present the magnitude of perception in terms of work experience. In this case also, the perception on the left hand is higher than on the right one.

Table 4 shows that the perception on the left hand is higher than the one on the right hand by values between 9% and 40%.

Fig. 7 and 8 present the subjects' perception magnitude in terms of temperature. In this case also the perception on the left hand is higher than on the right one.

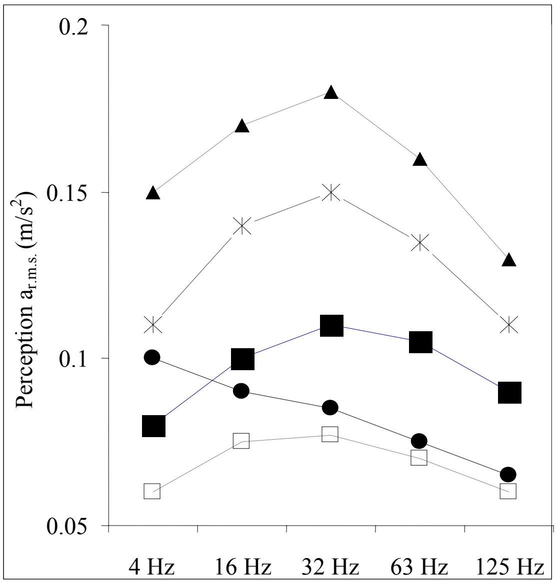

Fig. 3 Perception of acceleration for right hand.
(■) Thumb, (▲) Index, (x) Middle, (•) Ring, (□) Little.

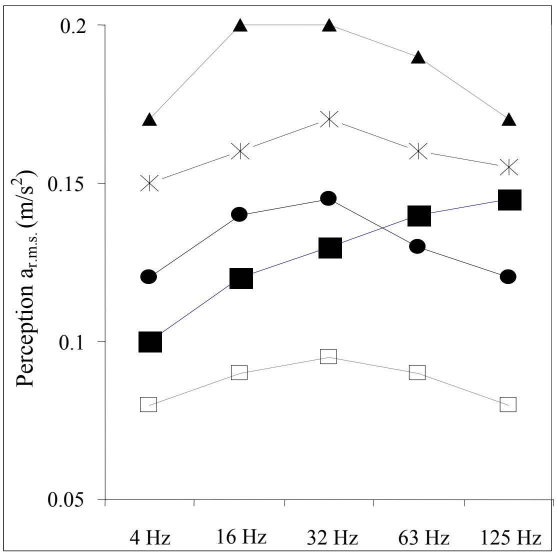

Fig. 4 Perception of acceleration for left hand.
(■) Thumb, (▲) Index, (x) Middle, (•) Ring, (□) Little.

Table 3 Perception of acceleration for right and left hand.

ν (Hz)	4 Hz		16 Hz		32 Hz		63 Hz		125 Hz	
Hand	r	l	r	l	r	l	r	l	r	l
Thumb	0.08	0.1	0.1	0.12	0.11	0.13	0.105	0.14	0.09	0.145
Index	0.15	0.17	0.17	0.2	0.18	0.2	0.16	0.19	0.13	0.17
Middle	0.11	0.15	0.14	0.16	0.15	0.17	0.135	0.16	0.11	0.155
Ring	0.1	0.12	0.09	0.14	0.085	0.145	0.075	0.13	0.065	0.12
Little	0.06	0.08	0.075	0.09	0.077	0.095	0.07	0.09	0.06	0.08

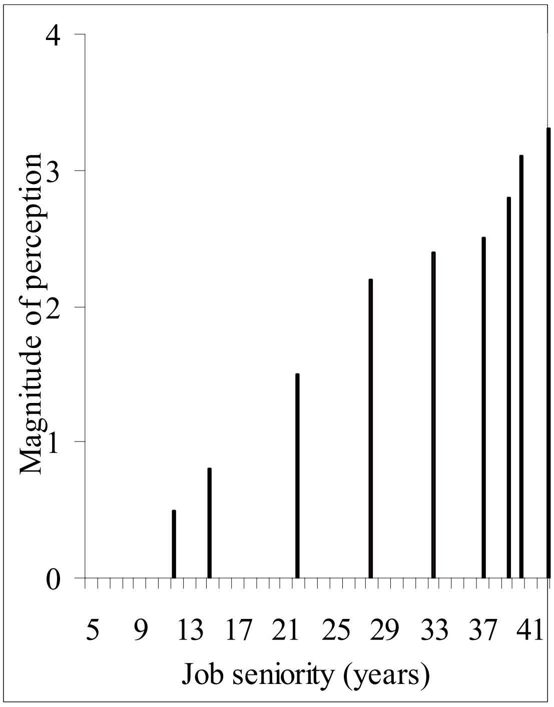

Fig. 5 Variation of magnitude perception for right hand in terms of work experience.

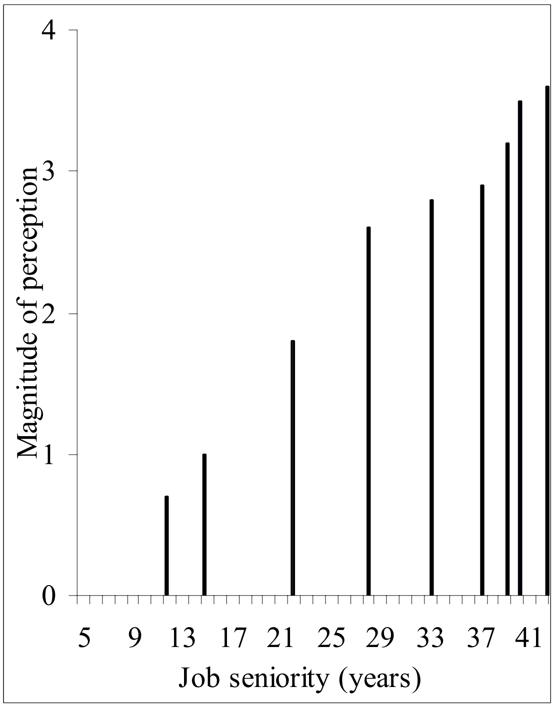

Fig. 6 Variation of magnitude perception for left hand in terms of work experience.

Table 4 Magnitude perception for right and left hand in terms of work experience.

Subject	S1		S2		S3		S4		S5		S6		S7		S8		S9		S10	
Hand	r	l	r	l	r	l	r	l	r	l	r	l	r	l	r	l	r	l	r	l
Work experience 5	0	0																		
12			0.5	0.7																
15					0.8	1														
22							1.5	1.8												
28									2.2	2.6										
33											2.4	2.8								
37													2.5	2.9						
39															2.8	3.2				
40																	3.1	3.5		
42																			3.3	3.6

The perception on the left hand is higher than on the right one by values between 25% and 47%. It can be also seen that the higher perceptions are felt at average temperatures, while at higher temperatures the perception decreases.

In this case it is extremely important the temperature

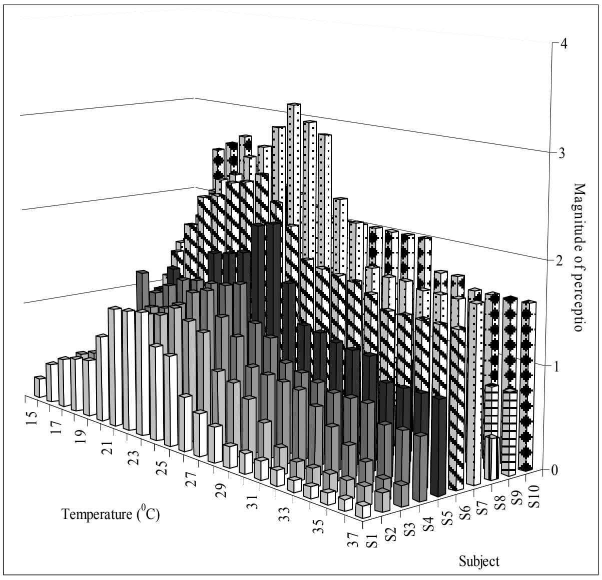

Fig. 7 Variation of magnitude perception for right hand on terms of temperature.

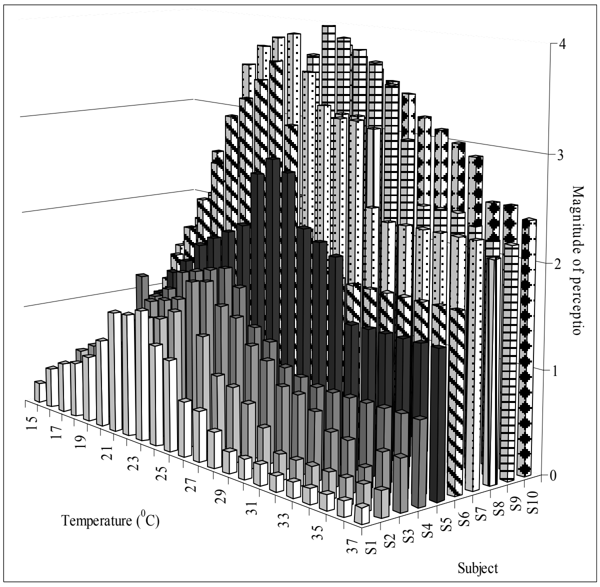

Fig. 8 Variation of magnitude perception for left hand on terms of temperature.

of the environment in which the subjects are working. If they are working outside, on winter time, when the hands are frozen anyway, they lose any sign of perception. If they are working outside, on summer time, the perception also decreases because of the total discomfort induced by high temperatures.

4. Conclusions

In order to make a correct and complete appraise of the vibrotactile sensibility of the men who are working in a HAV risk environment, it is necessarily to take into consideration, besides the vibrations' characteristics, a lot of other factors: equipment used, time spent in the vibrational environment, age, work experience, temperature of the environment social factors, medical history, etc..

For example, the effects of some other disease or of smoking can be mistaken by the effects of VWF but that doesn't mean that these factors do not contribute in some amount to the occurrence of VWF.

Also, the age of the worker has a great influence. Another important parameter is the temperature of the environment. This parameter should be around 20-30 °C but in most cases the temperatures are outside this range.

To avoid the occurrence of VWF it is absolutely necessarily the use of protective equipment and the rotation of working period with breaks.

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