

FUNDAMENTAL STUDY OF VIBROTACTILE PERCEPTION THRESHOLD ON JAPANESE- VIBROTACTILE PERCEPTION THRESHOLDS USING NEW MEASUREMENT EQUIPMENT

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1. INTRODUCTION

The ISO 13091-1 standard which was published in 2001 provides direction for the measurement of the vibrotactile perception threshold (VPT), using an internationally standardized method. A compilation of VPT data of healthy persons available at the time of publication are presented in ISO 13091-2:2003, Annex A, which were obtained with subjects in Europe and the US, and not with Japanese.

The purpose of this study is to investigate the VPT of healthy Japanese with new equipment developed according to ISO 13091-1, and compare the results with the ISO 13091-2:2003 reference data.

2. APPARATUS AND METHOD

2.1. Measurement Equipment Specification

New equipment developed according to ISO 13091-1:2001 was used. The equipment employs the “Method B: With surround”. The static contact force of the surround is kept constant (2 ± 0.3 N) by a spring. The contact force of the stimulator probe (6 mm diameter) is sensed and indicated so that the subject can easily keep the force constant (1 ± 0.3 N). The summarized specifications of the

equipment are as follows: -

Probe tip diameter: 6 mm

Probe contact force: 1 ± 0.3 N (indicator resolution: 0.1 N)

Surround diameter: 10 mm

Surround contact force: 2 ± 0.3 N

Stimulus frequency:

3.15, 4, 5, 20, 25, 31.5, 100, 125 and 160 Hz

Psychophysical algorithm: von Békésy and up-down

(von Békésy algorithm was used for the current study)

Measurement of finger temperature: 0.1 °C resolution

2.2. Subjects

The subjects were 30 males (age: 23 to 40 years) and 17 females (age: 22 to 40 years) healthy Japanese office workers, who do not have a history of undue exposure to vibration. The mean age of the male and the female subjects were 31.3 and 29.8 years respectively. The mean weights were 65.9 Kg (SD: 9.2 Kg) and 50.5 Kg (SD: 5.9 Kg). The mean heights were 172.5 cm (SD: 5.0 cm) and 158.6 cm (SD: 6.0 cm).

2.3. Experimental Conditions

The VPTs of index fingers and middle fingers of right-hands were measured for 9 stimulus frequencies (3.15, 4, 5, 20, 25, 31.5, 100, 125, and 160 Hz).

Table 1. VPT distributions for male and female subjects including index fingers and middle fingers.

	Frequency (Hz)								
	3.15	4	5	20	25	31.5	100	125	160
Males (60 fingers)	VPT (dB re 10^{-6} m/s ²)								
2.5 percentile	70.4	72.6	73.7	86.2	88.9	93.1	97.8	95.1	96.1
15 percentile	73.4	75.0	76.9	88.6	94.9	96.0	100.0	100.0	100.9
50 percentile	78.3	80.9	82.3	93.6	97.7	100.2	104.2	105.2	104.7
85 percentile	83.4	86.3	89.6	98.9	101.2	103.8	112.6	110.7	111.6
97.5 percentile	90.0	89.6	93.5	105.9	106.9	107.9	121.0	115.2	117.0
ISO 13091-2, Annex A	VPT (dB re 10^{-6} m/s ²)								
50 percentile	75.0	77.5	81.5	92.3	95.0	100.3	108.5	107.8	108.0
Females (34 fingers)	VPT (dB re 10^{-6} m/s ²)								
2.5 percentile	68.9	70.6	72.1	82.8	85.6	91.3	92.9	93.0	97.4
15 percentile	72.9	72.4	75.1	88.7	91.0	94.2	99.5	96.4	99.2
50 percentile	76.3	76.8	78.9	93.3	95.2	98.1	104.1	106.7	104.8
85 percentile	82.0	82.2	83.6	97.2	99.8	101.7	112.7	112.1	113.0
97.5 percentile	87.3	86.3	90.2	99.9	105.8	108.4	115.8	116.2	115.2
ISO 13091-2, Annex A	VPT (dB re 10^{-6} m/s ²)								
50 percentile				94.8		101.8		110.0	

The test room had concrete floor with plastic tiles, which prevented floor vibration influencing the VPT measurement. There was no vibration source nor noise source in the surroundings. The background noise levels were 42 dB (L_{Aeq}) measured with a sound level meter complying with IEC 16172 series. The averaged desk vibration was 66.5dB re $10^{-6}m/s^2$ for Wm Band-limiting according to ISO 2631-2:2003 (0.5 to 125 Hz). The floor vibration was lower than 50 dB.

The room temperatures were in the range from 20.5°C to 24.5°C throughout the experiment and the mean temperature was 22.8°C. The finger temperatures of the subjects were controlled to be within 27.0°C and 33.7°C and the mean temperature was 29.4°C.

3. RESULTS AND DISCUSSION

3.1. VPTs of Japanese Subjects

Table 1 shows 2.5, 15, 50, 85 and 97.5 percentiles of the VPT levels (expressed in decibels) of the male and the female subjects. The numbers of fingers are 60 and 34 because the VPT for the index fingers and the middle fingers are included. No large difference of the VPT levels is observed between the male and the female subjects, except that the VPT levels of the female subjects are a little lower than those of the males for some of the lower frequencies (3.15, 4 and 5 Hz). The largest difference of 50 percentile is 4.1 dB for 4 Hz. The largest difference in the table is that 85 percentile of the females is 6.0 dB lower than the males for 5 Hz.

Mean and standard deviation (SD) of the VPT levels for index fingers and middle fingers of the male and the female subjects are shown in Table 2. Significant differences at the 5 % significance level between the males and the females are measured only for some lower frequencies (t-test). Therefore, we consider that there is only a minor difference

between the VPTs of Japanese males and females.

3.2. Comparison of Current Study and ISO 13091-2 Reference Data

Table 1 refers to the 50th percentile of ISO 13091-2:2003, Annex A for comparison. The differences between the current study with Japanese subjects and the ISO data for the males and the females are up to 4.3 and 3.7 dB respectively. The VPT levels of the current study are generally higher for low frequencies and lower in high frequencies, which may be caused by minor differences of the test conditions.

4. CONCLUSION

VPTs were investigated with 30 male and 17 female Japanese subjects. Only small differences in VPTs are observed between the males and the females. We suggest that the possibility of using the same reference VPT levels for males and females for standard testing be considered.

The VPT data obtained by the current study with Japanese subjects show only minor differences from the reference data of ISO 13091-2:2003. Data for larger populations and various age groups need to be considered.

REFERENCES

- ISO 13091-1 (2001). *Mechanical Vibration: Vibrotactile Perception Thresholds for the Assessment of Nerve Dysfunction-Part 1: Methods of Measurement at the Fingertips* (International Organization for Standardization, Geneva).
- ISO 13091-2 (2003). *Mechanical Vibration: Vibrotactile Perception Thresholds for the Assessment of Nerve Dysfunction-Part 2: Analysis and Interpretation of Measurement at the Fingertips* (International Organization for Standardization, Geneva).
- Nakajima, R. et al., "Fundamental study of vibrotactile perception threshold on Japanese —New measurement equipment for vibrotactile perception", *12th Int. Conf on Hand-Arm Vibration*.

Table 2. Statistical comparison of VPTs for index fingers and middle fingers of male and female subjects (t-test).

		Frequency (Hz)								
		3.15	4	5	20	25	31.5	100	125	160
Males		VPT (dB re $10^{-6}m/s^2$)								
Index fingers (n = 30)	Mean	78.0	78.8	81.5	94.0	97.6	100.2	104.4	104.3	105.4
	SD	4.5	4.8	5.0	4.9	4.0	4.3	6.1	5.3	5.7
Middle fingers (n = 30)	Mean	78.7	82.0	83.6	94.6	98.3	100.4	106.5	105.7	106.1
	SD	5.7	4.8	5.5	5.7	4.7	4.6	5.8	5.8	5.1
Females		VPT (dB re $10^{-6}m/s^2$)								
Index fingers (n = 17)	Mean	75.3	76.5	78.0	92.4	95.9	97.8	104.7	104.9	105.0
	SD	3.9	3.8	3.3	4.6	5.5	4.2	6.5	6.3	5.8
Middle fingers (n = 17)	Mean	79.3	78.4	80.8	92.8	95.5	99.2	105.5	106.1	106.7
	SD	5.4	5.5	5.9	5.1	4.6	4.7	7.0	7.5	5.9
		Significant differences between males and females								
Index fingers	P<0.05	—	—	P<0.05	—	—	—	—	—	—
Middle fingers	—	—	P<0.05	—	—	—	—	—	—	—