The Hand and Environment

—Physiological Changes of Skin Temperature, Vibratory Sensibility and Pinch Strength of the Hand and Oxygen Uptake in Two Climatic Conditions—

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Abstract: Digital temperatures, pinch strengths, vibratory sensibilities, and oxygen uptakes of 21 healthy male adults in two age groups and under two climatic conditions were studied and compared. 1) The digital temperatures of the older age group were always a little higher than those of the younger age group. 2) Pinch strengths became slightly weakened in the 30°C chamber. 3) Vibratory sensibilities at 125 Hz became slightly sensitive in the 30°C chamber. 4) Oxygen uptakes were greater in the 10°C chamber.

Key words: digital temperatures, pinch strength, vibratory sensibility, oxygen uptake, age.

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Introduction

Recently, from the standpoint of clinical studies, health control and other medical examinations, there is a tendency for various functions of the hand to be recorded and evaluated by quantitative expressions.

Unfortunately, however, how these normal numerical data change with various environmental and individual conditions has not been clarified to date.

The authors undertook several basic experiments in order to obtain these numerical data. Digital temperature, vibratory sensibility, pinch strength and oxygen uptake, all of which have been utilized clinically by the authors, were selected as the parameters to evaluate the hand function. As environmental conditions, two room temperatures were maintained at different times in a climatic chamber. Data obtained from 21 healthy persons who were examined are reported and discussed in this paper.

Materials and Methods

A. Twenty-one healthy persons were studied in the experiment, which was undertaken in the winter of 1979. These persons were classified into two age groups, that

is, an older age group (10 persons older than 38) and a younger age group (11 persons younger than 30) (Table 1).

The older age group: Their ages ranged from 38 to 49 (mean: 43.2 ± 3.4 years), their body heights from 156 to 175 cm (mean: 165 ± 7.1 cm) and their body weights from 54 to 85 kg (mean: 68.4 ± 11.4 kg). The younger age group: Their ages ranged from 22 to 30 years (mean: 25.5 ± 1.7 years), their body heights from 160.5 to 174 cm (mean: 168.2 ± 3.8 cm) and their body weights from 50 to 68 kg (mean: 59.4 ± 5.7 kg). The majority of the 21 persons were right-handed.

Each person to be studied ate a 680-calorie lunch at noon. After evacuating their bladders, they put on 1.8 clo of clothing. Then, at 1.00 pm, they entered a climatic chamber, which was kept at 10°C and 50% relative humidity, and sat quietly for 30 minutes.

B. In order to record digital temperatures, tiny thermistors (0.8 cm in diameter, manufactured by Nihon Keisokuki Co.) were fixed comfortably on the dorsal surface of the proximal part of the terminal phalanx with adhesive plasters. Digital temperatures were measured only on the middle and ring fingers of both hands and recorded by an electronic automatic balanced recorder (manufactured by Nihon Keisokuki Co., Type EH 300-12).

When 30 minutes had elapsed since the person entered the chamber and digital temperatures were stabilized, the numerical data were measured. Vibratory sensibility was recorded in dB by stimulating a vibratory sensibility meter (manufactured by Rion Co., Type AU-02) at 125 and 250 Hz on the pulp of the terminal phalanx of both index fingers. Pinch strength was measured in kg by a pinch gauge (manufactured by J. A. Preston Co.) between the pulps of the index finger and the thumb, both of which were extended at the interphalangeal joints, of the right and left hands. Expiratory gas was collected into a Douglas bag for 5 minutes and the gas concentration of oxygen was analyzed with a gas analyzer.

C. Then, when the chamber temperature was changed to 30°C with the same 50% relative humidity, the above procedures were repeated.

These data were tabulated as a mean $\pm$ standard deviation and tested by a paired *t* test in this paper.

Table 1. Physical characteristics (mean $\pm$ S.D.) of the subjects

Subject group (No. examined)	Age (years)	Height (cm)	Body weight (kg)
Older (n:10)	43.2 ± 3.4	165.0 ± 7.1	68.4 ± 11.4
Younger (n:11)	25.5 ± 1.7	168.2 ± 3.8	59.4 ± 4.7
Paired <i>t</i> test	n. s.	n. s.	$P < 0.02$

Result

A. Experiment at the chamber temperature of 10°C (Tables 2, 3, 4, 5, 6 and 7)

The older age group showed skin temperatures of $19.0 \pm 4.1^\circ\text{C}$ on the right fingers and $18.4 \pm 3.6^\circ\text{C}$ on the left fingers, pinch strengths of 5.4 ± 0.8 kg in the right fingers and 5.1 ± 1.4 kg in the left fingers, vibration sensibilities of 2.0 ± 6.4 dB at 125 Hz on the right fingers, -0.25 ± 4.9 dB at 125 Hz on the left fingers, 11.75 ± 6.5 dB at 250 Hz on the right fingers and 6.25 ± 5.7 dB at 250 Hz on the left fingers, and oxygen uptake of 4.05 ± 0.66 ml/kg/min.

The younger group revealed skin temperatures of $16.3 \pm 2.1^\circ\text{C}$ on the right fingers and $15.9 \pm 1.7^\circ\text{C}$ on the left fingers, pinch strengths of 5.2 ± 1.4 kg in the right fingers and 5.2 ± 1.3 kg in the left fingers, vibration sensibilities of 3.64 ± 9.1 dB at 125 Hz on the right fingers, 3.64 ± 7.3 dB at 125 Hz on the left fingers, 14.32 ± 10.4 dB at 250 Hz on the right fingers and 14.09 ± 11.7 dB at 250 Hz on the left fingers, and oxygen uptake of 4.65 ± 0.51 ml/kg/min.

B. Experiment at the chamber temperature of 30°C (Tables 2, 3, 4, 5, 6 and 7)

The older age group exhibited skin temperatures of $34.0 \pm 1.0^\circ\text{C}$ on the right fingers and $33.6 \pm 0.9^\circ\text{C}$ on the left fingers, pinch strengths of 4.3 ± 0.7 kg in the right fingers and 4.3 ± 0.8 kg in the left fingers, vibration sensibilities of 0.5 ± 5.5 dB at 125 Hz on the right fingers, 0 ± 5.7 dB at 125 Hz on the left fingers, 5.0 ± 6.1 dB at 250 Hz on the right fingers and 4.5 ± 5.9 dB at 250 Hz on the left fingers, and oxygen uptake of 3.34 ± 0.59 ml/kg/min.

Table 2. Digital temperatures (means $\pm$ S.D.) at the two experimental temperatures

		10°C	30°C
Older	Right	19.0 ± 4.1	34.0 ± 1.0
	Left	$18.4 \pm 3.6^*$	33.6 ± 0.9
Younger	Right	16.3 ± 2.1	33.5 ± 0.3
	Left	$15.9 \pm 1.7^*$	32.4 ± 0.7
Paired t test		*: $P < 0.05$ (only on left side) n. s.	

Table 3. Pinch strengths (mean kg $\pm$ S.D.) at the two room temperatures, experimental temperatures

		10°C	30°C	Paired t test
Older	Right	5.4 ± 0.8	4.3 ± 0.7	$P < 0.02$
	Left	5.1 ± 1.4	4.3 ± 0.8	n. s.
Younger	Right	5.2 ± 1.4	5.1 ± 1.1	n. s.
	Left	5.2 ± 1.3	4.9 ± 0.9	n. s.

Table 4. Vibration sensibilities (mean dB at 125 Hz $\pm$ S.D.) at the two room temperatures

		10°C	30°C	Paired t test
Older	Right	2.0 $\pm$ 6.4	0.5 $\pm$ 5.5	n. s.
	Left	-0.25 $\pm$ 4.9	0 $\pm$ 5.7	n. s.
Younger	Right	3.64 $\pm$ 9.1	-1.36 $\pm$ 4.2	n. s.
	Left	3.64 $\pm$ 7.3	-3.18 $\pm$ 3.6	$P < 0.01$

Table 5. Vibration sensibilities (mean dB at 250 Hz $\pm$ S.D.) at the two room temperatures

		10°C	30°C	Paired t test
Older	Right	11.75 $\pm$ 6.5*	5.0 $\pm$ 6.1	$P < 0.05$
	Left	6.25 $\pm$ 5.7*	4.5 $\pm$ 5.9	n. s.
Younger	Right	14.32 $\pm$ 10.4	2.05 $\pm$ 4.4	$P < 0.01$
	Left	14.09 $\pm$ 11.7	1.59 $\pm$ 3.7	$P < 0.01$
Paired t test		*: $P < 0.05$		n. s.

Table 6. Oxygen uptake (mean ml/kg/min $\pm$ S.D.) at the two room temperatures

		10°C	30°C	Paired t test
Older		4.05 $\pm$ 0.66	3.34 $\pm$ 0.59	$P < 0.02$
Younger		4.65 $\pm$ 0.51	4.04 $\pm$ 0.32	$P < 0.01$
Paired t test		$P < 0.05$	$P < 0.01$	

Table 7. Digital temperatures (mean °C $\pm$ S.D.) and body weight at two room temperatures

Body weight	10°C		30°C	
	Right	Left	Right	Left
Less than 60 kg (n:11)	16.3 $\pm$ 1.7	15.9 $\pm$ 1.7	33.6 $\pm$ 1.2	32.5 $\pm$ 1.4
More than 61 kg (n:10)	19.0 $\pm$ 4.5	18.4 $\pm$ 3.5	33.8 $\pm$ 0.7	33.4 $\pm$ 0.7
Paired t test	n. s.	$P < 0.05$	n. s.	n. s.

The younger age group showed skin temperatures of $33.5 \pm 0.3^\circ\text{C}$ on the right fingers and $32.4 \pm 0.7^\circ\text{C}$ on the left fingers, pinch strengths of 5.1 ± 1.1 kg in the right fingers and 4.9 ± 0.9 kg in the left fingers, vibration sensibilities of -1.36 ± 4.2 dB at 125 Hz on the right fingers, -3.18 ± 3.6 dB at 125 Hz on the left fingers, 2.05 ± 4.4 dB at 250 Hz on the right fingers and 1.59 ± 3.7 dB at 250 Hz on the left fingers, and oxygen uptake of 4.04 ± 0.32 ml/kg/min.

C. Comparison between two age groups

The older age group was shorter in height and prominently heavier in body weight ($P < 0.02$) than the younger age group.

The digital temperatures of the older age group were always a little warmer than those of the younger age group, especially on the left fingers. And the right fingers were always recorded at higher temperatures than the left ones.

Pinch strengths between the pulps of the index fingers and the thumbs became slightly weakened in the 30°C chamber, especially in the right hands of the older age group ($P < 0.02$).

The vibration sensibility at 125 Hz became a little sensitive in the 30°C chamber, particularly in the left fingers of the younger age group ($P < 0.01$). The vibration sensibility at 250 Hz was clearly sensitized in the 30°C chamber, except for the left fingers of the older age group, and these differences were definite in the younger age group ($P < 0.01$). A strange difference between the right and left fingers was detected in the older age group in the 10°C chamber, in which the older age group was the more sensitive. Conversely, in the 30°C chamber, the younger age group became clearly sensitive, especially in the right fingers.

The oxygen uptake was higher in the 10°C chamber than in the 30°C chamber ($P < 0.02$).

Discussion

The older age group was shorter and significantly heavier than the younger age group. Under the two experimental temperatures, the digital temperatures of the older age group were always higher than those of the younger age group. The mural tension of the digital vessels might be reduced by aging. On the other hand, the digital temperatures in persons who weighed more than 61 kg were slightly higher than those in subjects who weighed less than 60 kg, especially on the left fingers in the 10°C chamber ($P < 0.05$), as shown in Table 7. The right digital temperatures tended to be higher than the left. This might be caused by the fact that the right hands were the dominant ones. Generally, the digital temperatures were clearly warmer than the room temperatures, and the differences between the digital and room temperatures were greater in the 10°C chamber than in the 30°C chamber.

Pinch strengths seemed to decrease slightly in the 30°C chamber. This tendency was more prominent in the older age group. On the other hand, Thorngren & Werner (1979) reported that grip strength decreases steadily with age. However, this tendency could not be proved in this study.

Vibrations stimulate, first of all, the quickly-adapting mechanoreceptors of the fingers, which are composed of paccinian corpuscles (sensitive at 60–300 Hz) and Meissner's corpuscles (sensitive at 2–40 Hz) as stated by Ito (1977). In the 10°C chamber, the vibration sensibilities seemed to be worsened, especially at 250 Hz, and the older age group was always more sensitive than the younger age group. Conversely, however, in the 30°C

chamber, the younger age group was more sensitive than the older age group. The quickly-adapting mechanoreceptors are connected to the myelinated A fibers, which have a diameter of between 8 and 15 μm and a conduction velocity of 40–70 m/sec as stated by Demichelis *et al.* (1979) and Ito (1977). Goodgold & Eberstein (1977) demonstrated that both motor and sensory conduction velocities may be lowered by 2–2.4 m/sec for each 1°C drop in temperature. Also, as reported (Dorfman & Bosley, 1979), in adult humans, peripheral nerve conduction velocity slows with advancing age at the rate of approximately –0.15 m/sec per year for motor fibers, and –0.16 m/sec per year for sensory fibers. A slight reduction in vibration sensation in persons over 30, especially after age 50, has been reported. Omer (1974) reported that these receptor organs vary with age, region of the body and occupation. One-fourth of all the pacinian corpuscles in the body are in the hands. Receptor organs are constantly dying or being destroyed. The best threshold for detecting vibration is oscillatory stimulation at 200–250 Hz.

The oxygen uptake was greater in the 10°C chamber than in the 30°C chamber in both age groups.

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手と環境

— 2 環境条件下での酸素摂取量, 手の指皮温, 振動覚, ピンチ力の生理学的変動 —

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要 旨: 健康成人男子 21 名の酸素摂取量, 手の指皮温, 振動覚, ピンチ力を 10°C および 30°C 人工気象室で測定し, 高令群と若年群とに分けて, 検討した. 1) 高令群では, 常に指皮温は若年群より高かった. 2) ピンチ力は, 30°C 室内で僅かに低下. 3) 125 Hz 振動覚は, 30°C 室内で僅かに過敏になった. 4) 酸素摂取量は, 10°C 室内で大きかった.

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