

## THERMAL COMFORT ZONES IN THE VIETNAMESE

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Thermally comfortable zones in Vietnamese were investigated during winter in Hanoi. The subjects were 21 males (age:  $19.7 \pm 0.4$  yrs; height:  $165 \pm 1.5$  cm; body mass:  $55.1 \pm 1.1$  kg) and 19 females (age:  $19.7 \pm 0.4$  yrs; height:  $155.6 \pm 1.7$  cm; body mass:  $45.6 \pm 1.3$  kg). Each participant entered singly the climatic chamber controlled at 22 °C and 40%RH. After 20 min rest, the participant was requested to indicate on a 7-point scale (Table 1) how he or she felt to the room temperature given. Then, the room temperature increased by 1 °C over 10 min every 20 min. Just before the rise of the room temperature, the participant judged his or her thermal sensation. More than 90% of the participants felt 24-29 °C of the room temperature as "slightly cool", "neutral" and "slightly warm" (Table 2). We defined these sensations as "thermally comfort". These thermally comfortable zones were quite higher than those (20-24 °C) recommended by ISO-7730 (1994). We discussed these discrepancies in terms of higher establishment of thermoregulatory set-point in the Vietnamese.

**Key Words:** thermal comfort; set-point; core temperature; Vietnamese

### INTRODUCTION

Most of the thermal comfort data have been studied on the North American and European subjects in climatic chamber experiments (ISO 7730, 1994; ASHRAE, 1985; 1995), and also have been applied on the Japanese population (ISO 7730, 1994), while the data on tropical people has not been discussed yet.

Vietnam is a tropical country with ambient temperature in the summer ranging from about 22 to 32 °C and in the winter from 13 to 23 °C and high relative humidity (Pham and Phan, 1978). These factors hinder the process of losing heat from the body, and this might influence the ambient temperature preferred by the Vietnamese for their thermal comfort (Mount et al., 1979). According to Nguyen et al. (2001), and Nguyen and Tokura (2002), the Vietnamese subjects had a significantly higher core temperature during the daytime than did Polish or Japanese subjects. Nguyen and Tokura (2003) also found that sweating onset occurred at a higher tympanic temperature in Vietnamese than Japanese subjects when both legs were immersed in warm water at 43 °C; that tympanic temperature was maintained at a higher level in the Vietnamese during this immersion; and that the local sweating rate was significantly lower in the Vietnamese. These findings strongly suggest that the set-point of core temperature had been established at a higher value in the Vietnamese subjects.

Bearing these results in mind, our hypothesis is that room temperatures associated with thermal comfort in tropical people such as the Vietnamese will be higher than those recommended by ISO-7730 (1970) standard as well. We discuss here the results from experiments that have been performed

to test our hypothesis.

## MATERIALS AND METHODS

The experiment was conducted in Hanoi (21°N), Vietnam during winter in 2002.

### *Participants*

Forty students volunteered as participants in our experiment. They were 21 males (age:  $19.7 \pm 0.4$  yrs, mean  $\pm$  SD; height:  $165 \pm 1.5$  cm; body mass:  $55.1 \pm 1.1$  kg) and 19 females (age:  $19.7 \pm 0.2$  yrs; height:  $155.6 \pm 1.7$  cm; body mass:  $45.6 \pm 1.3$  kg). All of them were free from taking drugs or medications, and the females were in the same phase of their menstrual cycles (follicular phase) to avoid any effects of reproductive hormones on body temperature (Bell et al., 1999). All experimental procedures were fully explained to them before the experiments and their informed consent was given.

### *Experimental clothing*

The participants wore short-sleeved T-shirt and full-length trousers made of 100% cotton.

### *Experimental protocol*

Each participant entered singly a bioclimatic chamber, which was controlled at 22 °C and 40% relative humidity. After 20 min rest, the participant was asked to indicate on a 7-point scale his or her thermal sensation (Table 1). The room temperature was then increased by 1 °C over 10 min every 20 min. Just before each change, the participant was requested to indicate his or her thermal sensation, using the same scale. The procedure continued until the participant reported that he or she felt warm. Then, a further 1 °C increase in room temperature was applied in order to confirm the warm sensation. During the whole period of the experiment the participant sat quietly in a chair, reading books.

Table 1. Seven-point thermal sensation scale.

+3	Hot
+2	Warm
+1	Slightly warm
0	Neutral
-1	Slightly cool
-2	Cool
-3	Cold

## RESULTS AND DISCUSSION

More than 90% of the Vietnamese participants perceived the room temperatures from 24 °C to 29 °C as slightly cool, neutral and slightly warm (Table 2). Judging from the statement that “thermal comfort” means that an individual feels neither too cool nor too warm (Fanger, 1973a; 1973b), we defined these thermal sensations as thermally comfort. These comfort zones were clearly higher than the ones (20-24 °C) recommended by ISO-7730 (1994). These comfort zones depend on the combination of four environmental parameters (air temperature, mean radiant temperature, air velocity and air humidity) with two other parameters related to the physical activity of the individual and his/her clothing (ISO-7730, 1994).

According to ISO-7730 (1994), the thermal conditions that are acceptable by more than 80% of

Table 2. Number of participants who felt comfort under the influence of rising room temperatures at 40% of relative humidity.

Room temp. (°C)	Number of participants who felt comfort						Total (N = 40)	%
	Male (n = 21)			Female (n = 19)				
	Slightly cool	Neutral	Slightly warm	Slightly cool	Neutral	Slightly warm		
22	10	1	1	3	2	0	17	42.5
23	8	5	0	4	7	2	26	65
<i>24</i>	7	7	<i>5</i>	7	<i>11</i>	<i>1</i>	<b>38</b>	<b>95</b>
<i>25</i>	4	<i>11</i>	<i>5</i>	3	<i>10</i>	<i>6</i>	<b>39</b>	<b>97.5</b>
<i>26</i>	4	7	<i>10</i>	<i>1</i>	6	<i>12</i>	<b>40</b>	<b>100</b>
<i>27</i>	2	4	<i>15</i>	<i>1</i>	3	<i>15</i>	<b>40</b>	<b>100</b>
<i>28</i>	2	2	<i>16</i>	<i>1</i>	5	<i>13</i>	<b>39</b>	<b>97.5</b>
<i>29</i>	<i>1</i>	<i>1</i>	<i>17</i>	<i>0</i>	2	<i>15</i>	<b>36</b>	<b>90</b>
30	1	0	5	1	0	3	10	25

Italic and bold letters indicate the number of the participants in the comfort zones, which is situated within more than 90% out of all participants

sedentary participants are between 20 °C and 24 °C (operative temperatures) with a relative humidity between 30% and 70% and an air velocity of less than 0.28ms<sup>-1</sup>. Operative temperature can be calculated approximately as the mean value of air and mean radiant temperatures, if the air velocity is small (<0.2ms<sup>-1</sup>) and the difference between the mean radiant and air temperature is small (<0.4 °C). Applying these rules to the thermal conditions in the present experimental room, the recommended temperature may be regarded as approximating to the air temperature.

Why did the Vietnamese perceive room temperatures as comfortable that were higher than that recommended by ISO-7730? Nguyen et al. (2001) and Nguyen and Tokura (2002; 2003) reported that the core temperature was significantly higher in Vietnamese than in Polish and Japanese participants, suggesting that the set-point of core temperature for the Vietnamese might have been established at a higher level. Also, Kim and Tokura (1997) found that women during the luteal phase preferred a higher room temperature for thermal comfort than during the follicular phase. Moreover, during cold exposure to 15 °C, women dressed more quickly and heavily during the luteal than the follicular phase (Kim and Tokura, 1995). These suggest that the higher set-point of core temperature during the luteal phase could make women search for more warmth both by selecting a higher room temperature and by wearing more thicker clothes. Detailed discussion was made elsewhere (Kim and Tokura, 1995; 1997). Briefly to summarize, this behavior is advantageous for an approach of the actual core temperature to raised thermoregulatory set-point. Therefore, it is suggested that the underlying physiological basis for our finding that more than 90% of the Vietnamese participants felt the room temperatures ranging from 24 °C to 29 °C as thermally comfortable is due to an establishment of a higher set-point for core body temperature. Physiological and ecological significance of an establishment of higher set-point for core temperature in the Vietnamese has been fully discussed elsewhere (Nguyen et al., 2001; Nguyen and Tokura; 2002; 2003).

## REFERENCES

- ASHRAE (1985) Physiological principles for comfort and health (Chapter 8). *In: Fundamental Handbook* (American Society of Heating, Refrigeration, and Air-Conditioning Engineers: Atlanta).
- ASHRAE (1995) Addendum to "Thermal Environmental Conditions for Human Occupancy". ANSI/ASHRAE Standard 55-1992a (American Society of Heating, Refrigeration, and Air-Conditioning Engineers: Atlanta).
- Bell, DG, Jacobs, I, McLellan, TM, Miyazaki, M, and Sabiston, CM (1999) Thermal regulation in the heat during exercise after caffeine and ephedrine ingestion. *Avian Space Environ. Med.* **70**: 583-588.
- Fanger, PO (1973a) *Thermal Comfort*. McGraw Hill Co., New York.
- Fanger, PO (1973b) Assessment of man's thermal comfort in practice. *Br. J. Ind. Med.* **30**: 313-324.
- Fanger, PO, Ostberg, O, Nicholl, McK, Breum, NO, and Jerking, E (1974) Thermal comfort conditions during day and night. *Eur. J. Appl. Physiol.* **33**: 255-263.
- ISO 7730 (1994) International Organization for Standardization: Moderate thermal environments – Determination of the PMV and PPD indices and specification of the conditions for thermal comfort.
- Kim, HE and Tokura, H (1995) Effects of menstrual cycle on dressing behavior in the cold. *Physiol. Behav.* **58**: 779-783.
- Kim, HE and Tokura, H (1997) Preferred room temperature self-selected by women under the influence of the menstrual cycle and time of day. *Biol. Rhythm. Res.* **28**: 417-421.
- Mount, LE (1979) *Adaptation to Thermal Environment*. Edward, London: pp. 145-159.
- Nguyen, MH, Rutkowska, D, and Tokura, H (2001) Field studies on circadian rhythm of core body temperature in tropical inhabitants compared with those in European inhabitants. *Biol. Rhythm. Res.* **32**: 547-556.
- Nguyen, MH and Tokura, H (2002) Observations on normal body temperatures in the Vietnamese and the Japanese in Vietnam. *J. Physiol. Anthropol.* **21**: 59-65.
- Nguyen, MH and Tokura, H (2003) Sweating and tympanic temperature during warm water immersion compared between Vietnamese and Japanese living in Hanoi. *J Human Ergol.* **32**: 9-16.
- Pham, NT and Phan, TD (1978) *Vietnam Climate*. Hanoi City Press, Hanoi (in Vietnamese).