

# THE OPTIMAL AMBIENT TEMPERATURE FOR BATHING JUDGED FROM PHYSIOLOGICAL AND PSYCHOLOGICAL RESPONSES

Hikaru Enomoto-Koshimizu<sup>1)</sup>, H. Ozaki<sup>2)</sup> and Y. Tochihara<sup>3)</sup>

- 1) National Institute Post Doctoral Fellow, Department of Physiological Hygiene, National Institute of Public Health, Tokyo, 108, Japan
- 2) Life Support System Section, Aeromedical Laboratory, Japan Air Self Defense Force, Tokyo, 190, Japan
- 3) Department of Physiological Hygiene, National Institute of Public Health, Tokyo, 108, Japan

## INTRODUCTION

By the bathing, the human body suffers physiological influences, like body temperature rising, metabolism increasing, blood pressure decreasing by vascular expansion, heart rate increasing, and others. From the published "Sudden death" statistics information section, the Ministry of Welfare in Japan, reveals that the number of deaths by drowning while bathing in the bathroom is higher than that while at sea, especially among the elders. This may be due to the difference in ambient temperature between the bathroom, the dressing room, and the living room (Kanda et al. 1995<sup>1)</sup>).

Series of experiments were conducted to investigate the optimal room air temperatures for bathing judged from physiological and psychological responses.

## METHODS

1. **Environmental conditions:** Experiments were carried out in summer and winter in climate chambers, where two chambers were connected to the bathroom. The ambient temperature of one room was set at 25°C as a pre-room of the subjects, and the other room was set at temperatures ( $T_a$ ) of 15, 19, 23, 27, or 31°C as a experimental room before and after taking a bath. The water temperature of the bath was kept constant at 41°C. Relative humidity of both rooms was set at 50%.

2. **Subject conditions:** Eight female university students participated in the experiments as subjects. The subjects stayed in pre-room or bathroom in bikini before and during bathing, and in T-shirts and short pants after bathing. In the pre-room and experimental room, the subjects sat on chairs and remained quiet.

3. **Measurements and time schedule:** Rectal and skin temperatures at 7 points of

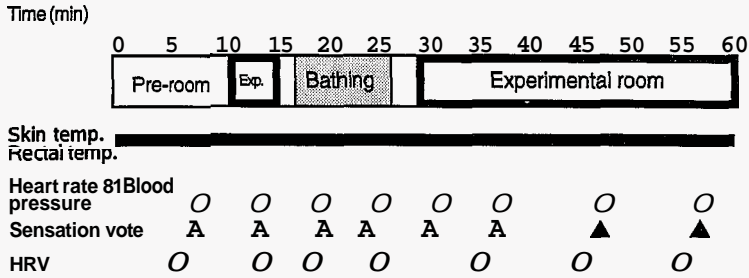


Fig 1. Time Schedule

the subjects were measured continuously during the experiments, and mean skin temperature was calculated by weighing the temperatures using the formula of Hardy-DuBois. Blood pressure, heart rate, thermal and comfort votes, and heart rate variability were also recorded every 5 or 10 minutes.

After the subjects stayed more than 30 minutes in the pre-room in bikini, T-shirts and short pants, the measurement was started. Ten minutes later, they moved to the experimental room and were in bikini for five minutes. After that, they **took** a bath for ten minutes during which they were immersed up to their neck in a Japanese-style bathtub. During the bathing period the subjects were sitting quietly, then got dressed and remained in the experimental room for another 32 minutes.

**4. Data analysis:** Each pair of group means was compared using paired t-test or analysis of variance to determine the significance of the differences. The significance level was set at  $p < 0.05$ .

## RESULTS

1. **Mean skin temperatures:** Means of mean skin temperature at each  $T_a$  were presented in Fig.2. Mean skin temperatures in the pre-room were approximately  $33^\circ\text{C}$ , and in the experimental room before bathing, they increased or decreased because of the difference of  $T_a$ . During taking a bath, means became  $39.5^\circ\text{C}$ . After returning to the experimental room, the means decreased to  $34^\circ\text{C}$  rapidly and after thirty minutes of exposure, they became higher or lower again because of the  $T_a$ .

The relationship between  $T_a$  and mean skin temperatures at each time in the experimental room were shown in Fig.3 At each time, significant relationships were observed. After bathing, the slopes became steeper with time after bathing.

2. **Rectal temperatures:** Means of the rectal temperatures at each  $T_a$  were distributed

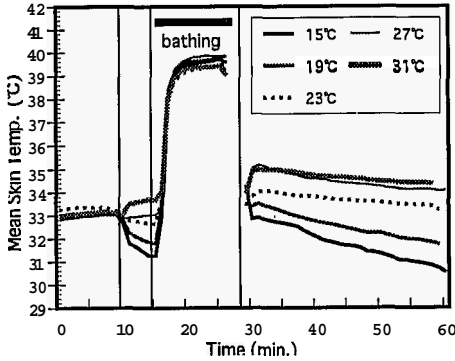


Fig 2. Changes in the mean skin temperatures

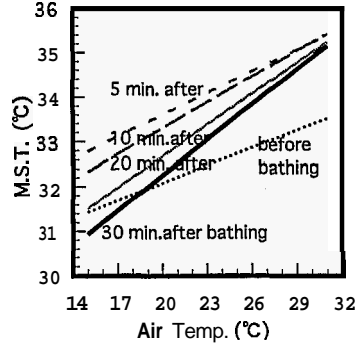


Fig 3. Relationship between  $T_a$  and mean skin temperature

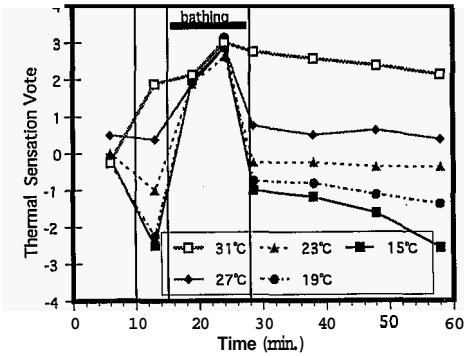


Fig 4. Changes in the thermal sensation vote

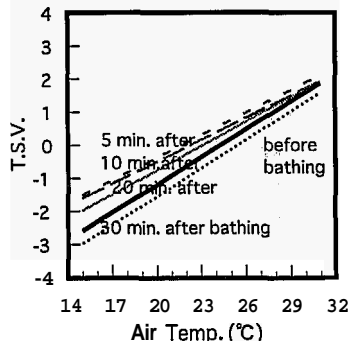


Fig 5. Relationship between  $T_a$  and thermal sensation vote

from 37.3°C to 37.8°C. The influence of bathing could be seen as the rise of the means, however, there was no significant difference between  $T_a$  or time by analysis of variance.

**3. Thermal sensation vote:** Means of the thermal sensation vote at each  $T_a$  were presented in Fig.4. Before bathing, thermal sensation votes were distributed from "-3: Cold" to "+2: Warm", and then became "+3: Hot" during bathing. After returning to the experimental room, the change in means were influenced by  $T_a$  and decreased by a grade in thirty minutes.

The relationship between  $T_a$  and thermal sensation votes at each time in the experimental room were shown in Fig.5. At each time, significant relationships were

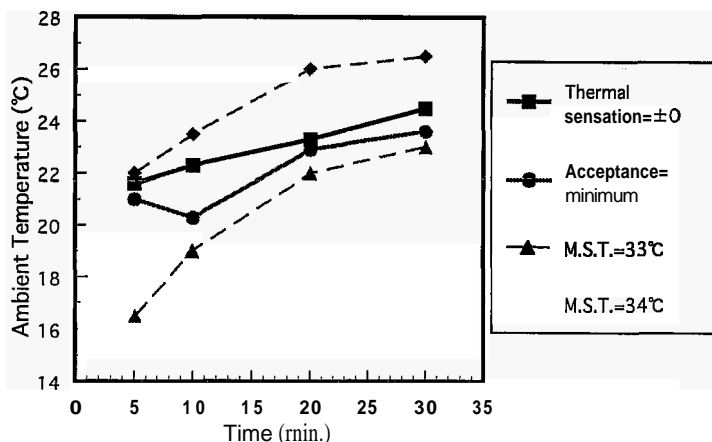


Fig 6. Change in the optimal temperature

observed. Same as the mean skin temperatures, the slopes became steeper with time after the bath.

**4. Difference between the seasons:** The means of the mean skin temperatures before bathing in winter were lower than those in summer, and it was supposedly affected by the low local skin temperatures on the hand or foot. However, there were no significant differences in other parameters between the seasons.

## CONCLUSIONS

Fig.6 shows the changes in optimal thermal conditions after bathing judged from mean skin temperature, thermal sensation vote, and acceptance of the thermal environment. The optimal temperature after the 5 minutes of bathing was approximately from 16°C to 22°C. However, the temperature changed to 23°C or 24°C at the end of the experiments. Since distinct negative responses were not seen in blood pressures or heart rate variability, at this temperature, it can be concluded that the optimal room air temperature before and after bathing may be 23-24°C.

## REFERENCE

1. Kanda, K., Tsuchiya, J., Seto, M., Ohnaka, T., Tochihara, Y., 1995, Thermal conditions in the bathroom in winter and summer, and physiological responses of the elderly during bathing. *Japanese Journal of Hygiene*, 50, 595-603.