Effects of Water Temperature during Foot Bath in Young Females

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ABSTRACT
We examined the effects of environmental and water temperatures of foot baths on pulse rate, blood pressure, mean skin temperature, salivary amylase (SA) activity, relaxation level and thermal sensation during winter. Five females participated in the study. The subjects rested in a chair for 20 min and the above-noted physiological reactions during the last 5 min of the resting period were recorded as baseline (BASE) values. Next, the subjects received a 15-min foot bath in water at 40 °C (WT40) or 45 °C (WT45), with a 15-min recovery period. Although SA is thought to be an indicator of stress via the sympathetic nervous system, we did not find a correlation between SA activity and relaxation state. We considered the possible effect of seasonal variation on the physiological reaction to foot bathing.

Key words foot; immersion; salivary alpha amylase; seasonal variation; thermosensing

Foot immersion is particularly effective for inducing relaxation and sleep. We hypothesized effects of environmental and water temperatures and seasonal variation on the physiological reaction to foot bathing, and examined the effects of both temperatures of foot baths on pulse rate, blood pressure, mean skin temperature, salivary amylase (SA) activity, relaxation level and thermal sensation during the winter.

SUBJECTS AND METHODS
Five female subjects participated in the study (age, 20.5 years, ±1.0; height, 157.2 cm, ±9.3; body weight, 53.9 kg, ±6.5; body fat, 26.9%, ±1.8). This study was approved by the Ethics Committee of Tottori University (approval number 2074).

All subjects wore T-shirts and shorts during the experiment. The room temperature was maintained at 20 °C. The subjects each rested in a chair for 20 min; pulse rate, blood pressure, mean skin temperature, SA activity, relaxation state and thermal sensation during the last 5 min of the resting period were recorded as baseline (BASE) values. Next, the subjects received a 15-min foot bath in water at 40 °C (WT40) or 45 °C (WT45), with a 15-min recovery period. Pulse rate, blood pressure and skin temperature were measured by digital electronic sphygmomanometer ES-P110 (Terumo, Tokyo, Japan) at the end of BASE recording and at 5, 10 and 15 min of the foot immersion and recovery periods.

Skin temperatures were obtained from the chest, arm and thigh using thermistor thermometer NT Logger N542R and thermistor probe ITP082-25 (NIKKISO- THERM, Tokyo), and mean levels were calculated.1 SA activity was measured by Salivary Amylase Monitor (NIPRO, Osaka, Japan) at each end of BASE recording, foot immersion and recovery periods. SA activity is used as an indicator of stress via the sympathetic nervous system.2, 3 The relaxation level and thermal sensation of the whole body and foot were similarly measured on a numerical rating scale. Foot baths under each condition (WT40 and WT45) were performed between 1100 hours and 1300 hours on different days, but always at the same time. The room temperature was maintained at 20 °C.

All data were presented as mean and standard deviation. A two-way analysis of variance with repeated measures was used to test for a physiological difference between water temperatures. Tukey’s post-hoc test was used to test significant differences. The subjective scale was assessed by the Friedman and Wilcoxon signed rank tests. The data were analyzed using the PASW Statistics software for Windows ver. 18.0 (IBM, Tokyo, Japan). The significance level was set at P < 0.05.

RESULTS AND DISCUSSION
Compared to the BASE values, the pulse rate and systolic and diastolic blood pressures did not change under either bathing condition. Foot immersion probably puts a less severe load than usual bathing does on the circulatory system, and it induces hyperthermia.4 The main effect of time was significant for the mean skin temperature (P < 0.05). Mean skin temperature was

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Abbreviations: BASE, baseline recorded during the last 5 min of the 20-min resting period; SA, salivary amylase; WT40, 15-min foot bath in 40 °C water; WT45, 15-min foot bath in 45 °C water
affected by the heat stimulation of the foot bath under both temperature conditions.

The main effect of water temperature was not significant for SA activity ($P = 0.057$) (Fig. 1a). We considered the possibility that cardiac vagal modulation was enhanced under the WT45 condition. We did note a different result when the experiment was performed in summer.

Compared to the BASE values, the relaxation level (Fig. 1b) and thermal sensation of the whole body and foot under both conditions increased significantly during the foot immersion and recovery periods. *$P < 0.05$ versus BASE.

BASE, baseline recorded during the last 5 min of the 20-min resting period; Immersion15, measurement at the end of a 15-min foot immersion period; Recovery15, measurement at the end of a 15-min recovery period; SA, salivary amylase; WT40, 15-min foot bath in 40°C water; WT45, 15-min foot bath in 45°C water.

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