Circadian Variations of Sweating in Man Exposed to Thermal Stimuli

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Sweating is one of the most effective methods in heat loss. The circadian rhythm of body temperature is thought to be the result of a rhythm in total body heat content which reflect a rhythmic imbalance between heat production and heat loss. The sweating mechanism may be, therefore, variable at different times of day along with such a rhythm, and the circadian changes of sweating rate have been described during physical exercises (Stephenson et al., 1984; Westin, 1976) or under heat conditions (Timbal et al., 1975; Marotte and Timbal, 1982). In the present report, the characteristics of sweating and the thermal state were investigated at three different times of day in the human subjects who had daily sleep-wake schedules shifted for a few hours.

METHODS

Four Japanese male students, aged 22 to 23 years, were employed in this study. They had stayed up late at night and had woken up in the late morning or before noon almost every day for the past two or three years. Each subject stayed in the laboratory (18—22°C) two times, from 1200 of the first day to 1000 of the second day, and from 2000 of the first day to 1700 of the second day, respectively. The order of these stays was changed in each subject, and there was at least one week between the primary and secondary stays. The experiments of heat exposure were carried out in the climate chamber (40°C, 50% R.H.) during 0800—0900 (a.m.), 1600—1700 (p.m.), and 0000—0100 (night) in each stay. The subjects slept during 0130—0730, and had a meal immediately after each experiment.

The subjects rested at least 45 minutes before the thermal exposure, entered the climatic chamber, and continued to rest for 60 minutes in the chair. During the last five minutes before the thermal exposure and 60 minutes in the climate chamber, the subjects dressed in shorts. Their sweating rate (SR), rectal temperature (Tr) and skin temperatures (Ts) were measured every three minutes. Rectal and skin temperatures were measured with the thermisters. Sweat was collected with the filter paper method (Ohara, 1968) on the right chest, and the sweating rate was determined as the volume of sweat collected per three minutes. Mean skin temperature was calculated from the equation of Ramanathan (1964).

All data were then analyzed by a two-way ANOVA across time, individuals and interaction.

RESULTS AND DISCUSSION

The variation of Tr at the end of rest before the heat exposure (Tr(rest)) was highly significant, with the lowest temperature at a.m. and the highest at night (Fig. 1). The phase of rhythmic pattern in the internal temperature partially depends on the types of morningness and eveningness in the daily sleeping-waking pattern from the self-assessment questionnaire (Horne and Ostberg, 1976). All subjects in the present study were the eveningness types from their daily sleep-wake schedules and their Tr(rest) patterns. Tr at the end of the heat exposure was also tended to be highest at night and to be lowest at a.m., but the difference among these times
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Fig. 1. Rectal temperature at the end of rest before the thermal exposure at three times of day. H, S, T and N: Mean value in each subject.

Fig. 2. Latent period of sweating at three times of day. The latent period of sweating was determined as the period from the onset of the heat exposure to the time at which the SR was greater than 5mg/23.8cm²/3min. N, H, T and S: Mean value in each subject.

was not significant.

Ts did not show a consistent pattern before or during the heat exposure of the different times.

Sweating was not observed during all the rest periods before the heat exposure and almost during the initial period of the heat exposure. There was no significant difference of the mean SR among times except for the individual difference, although the mean SR tended to be higher at p.m. The latent period of sweating (Psw) was significantly longest at a.m. and shortest at p.m. (Fig. 2).

Previous studies have reported that Psw was not significantly altered in the evening (1800) but significantly shortened in the night (0200) compared with in the morning (1000) during a heat exposure (Timbal et al., 1975), or Psw was longest in the early afternoon and shortest in the midnight during a heat exposure (Marotte and Timbal, 1982). These variations have generally tended to be parallel with the variations of the body temperatures. But, in the present study, Psw was significantly shortest at p.m., and the difference between a.m. and p.m. was relatively greater than the difference between p.m. and night. And the variation of Psw was not parallel with the variation of Tr(rest). The phase of rhythmic pattern in Tr(rest) of the subjects was shifted for a few hours compared with other descriptions of the circadian rhythm of body temperature in the normal sleep-wake schedules. The longer Psw in the lower Tr may be due to such a shifted phase of sleep-wake cycle.

REFERENCES


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