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Observations on Normal Body Temperatures in Vietnamese and Japanese in Vietnam

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Abstract The observations described in this paper were made during a study of the effects of tropical climate upon Vietnamese and Japanese. We measured rectal and skin temperatures every 10 min for 26 hrs in 6 Vietnamese and 6 Japanese. The experiments have been conducted for 2 hot months, June and July 1999 and 2000 in Hanoi, Vietnam. The ambient temperatures ranged from 33 to 36°C. The results obtained are summarized as follows: 1) Skin temperatures at thigh, forearm and hand during the daytime were significantly higher in the Vietnamese subjects than in the Japanese ones. It would be physiological reactions to warm ambient temperatures, which is advantageous for dissipation of body heat. 2) The average rectal temperature during the daytime is significantly higher in the Vietnamese than in the Japanese, while significantly lower at night. 3) Average range of oscilation of rectal temperature was 1.26°C in the Vietnamese, which was clearly greater than in the Japanese. The higher core temperature, which was actively regulated under warm temperature, seemed of adaptive significance, resulting in the reduction of water consumption like camels in the desert. A greater range of oscillation in tropical Vietnamese people might have ecological significance for efficient acclimatization in the warm environment, suggesting that the setpoint of core temperature could show a greater range of oscillation. *J Physiol Anthropol 21 (1): 59-65, 2002* http://www.jstage.jst.go.jp/en/

Keywords: body temperatures, setpoint, circadian rhythm, tropic

Introduction

Acclimatization to the tropic associated with higher internal temperature in humans has been discussed by many authors (Davy, 1850; Sundstroem, 1927; Mason 1940; Renbourn, 1946; Adam and Ferres, 1954; Ladell, 1964). However, there are a few studies on acclimatization to the torrid climate from the viewpoint of circadian rhythm.

The circadian rhythm of body temperature in humans is a well documented biological phenomenon (Aschoff and Heise, 1972; Hildebrandt, 1974). An overt circadian rhythm consists of endogenous and exogenous components; the endogenous component is determined by the activity of the body clock and the exogenous component is results from environmental conditions and lifestyle (Minors and Waterhouse, 1993). Ambient temperature (T_a) and light exert important effects on the circadian rhythm of core temperature (Aschoof and Heise, 1972; Honma et al., 1987; Minors et al., 1991; Park and Tokura, 1998). Recently, Nguyen et al. (2001) have reported that the internal temperature in tropical Vietnamese inhabitants, who are repeatedly exposed to high T_a and bright light intensity was higher than that in Polish during the daytime, while lower in the nighttime. It may be that the higher rectal temperatures (T_{re}) during the daytime helps water saving, while the lower T_{re} at night helps good sleep. These results encourage us to investigate whether the circadian rhythm of core temperature in unacclimatised Japanese under the tropical climate might be similar to that in Polish in comparison to Vietnamese.

Skin temperatures are also higher in the tropical inhabitants as noted by Sundstroem (1927). We hypothesize that the skin temperatures might be higher in Vietnamese than in Japanese. It would be physiological reactions to warm T_a for dissipation of body heat.

To know how different the circadian rhythms of skin temperature and T_{re} are between Vietnamese and Japanese, the experiments were conducted in Vietnam during the summer time, June and July 1999 and 2000. Vietnam runs between the 103rd and 109th meridian of longitude below Tropic of Cancer in the North Hemisphere and its climate is defined as monsoon tropical climate.

Methods

Participants

Six Vietnamese inhabitants including 5 males and a female (20–22 yrs old, 166.8 ± 3.2 cm, mean ± SEM, for height, 56.3 ± 3.1 kg for weight, 1.7 ± 0.1 m^2 for body surface area, 1.2 ± 2.6 for Rohrer index, RI, 2 ± 0.5 for body mass index, BMI) volunteered as participants in the experiment in Vietnam and 6 Japanese including 4 males and 2 females (23–28 yrs old, 166.8 ± 2.3 cm, 57.3 ± 2.5 kg, 1.6 m^2, 1.2 ± 2.8, 2 ± 0.5). No significant differences in physical characteristics between two groups were found. All Japanese participants had been in Vietnam for two to four months. All of them were students and had a normal sleep-wake cycle. They were drug-free, nonsmokers and synchronized to a similar schedule: they slept daily from 23:00 until 07:00 for a week prior to participation in this present study. Air conditioning is not used during the summer period in Vietnam. Clothing worn and bed clothes were the same for both groups of participants. The female participants served during the follicular phase of the menstrual cycle. The purpose and procedures of the experiments were fully explained to them before the experiments and their informed consent was obtained.

Body surface area was calculated by the equation for Vietnamese (BinhDy et al., 1982): BSA = $W^{0.368} * H^{0.832} * 53.65 * 10^{-4}$, and for Japanese (Fujimoto et al., 1968): BSA = $W^{0.444} * H^{0.663} * 88.83 * 10^{-4}$, where W is weight (kg), H is height (cm) and BSA is body surface area (m^2).

Rohrer index was calculated by Rohrer's equation: RI = $W / H^3 * 10^5$, where RI is Rohrer index, W is weight (kg) and H is height (cm).

Measurements

Measurements were performed during the summer, June and July 1999 and 2000, in Vietnam. Two participants were simultaneously studied. The average T_a was 34.6 ± 0.5°C. T_a was measured using a thermistor sensor (Gram Cooporation Thermistor Sensor, Japan; accuracy, ± 0.1°C). The thermistor sensor was put in the vicinity of the participants. The light intensity was measured every three hr by an illumination meter IM-2D (Topcon Ltd, Japan, measurement of scale 0.1–19,999 lx). It was measured near a subject's eye when looking towards. The average light intensity during the daytime is over 16,000 lx and of 100 lx was set until 23:00 h at bedroom, where the subjects spent time after supper. A wet and dry bulb thermometer (Nikkei, Japan) was used to estimate relative humidity. The average humidity was 83%. Wind speed at the housetop, which was measured by a wind speed meter (Model CW-20, Custom Corporation, Japan) was 2.8 m. s^{-1}.

Rectal temperature (T_{re}) was measured by a thermistor sensor (Gram Cooporation Thermistor Sensor, Japan; accuracy, ± 0.01°C). This thermistor sensor was inserted by subjects themselves 12 cm beyond the anal sphincter. Skin temperatures were measured with thermistor sensors (Gram Cooporation Thermistor Sensor, Japan; accuracy, ± 0.1°C) taped at seven sites: forehead, chest, forearm, hand, thigh, leg and foot. All the parameters for temperatures were recorded every ten min throughout the experiment. Mean skin temperature (T_{sk}) was calculated by the following modification of the Hardy DuBois equation for seven sites (Hardy and DuBois, 1938): $T_{sk} = 0.07T_{forehead} + 0.35T_{chest} + 0.14T_{forearm} + 0.05T_{hand} + 0.19T_{thigh} + 0.13T_{leg} + 0.07T_{foot}$.

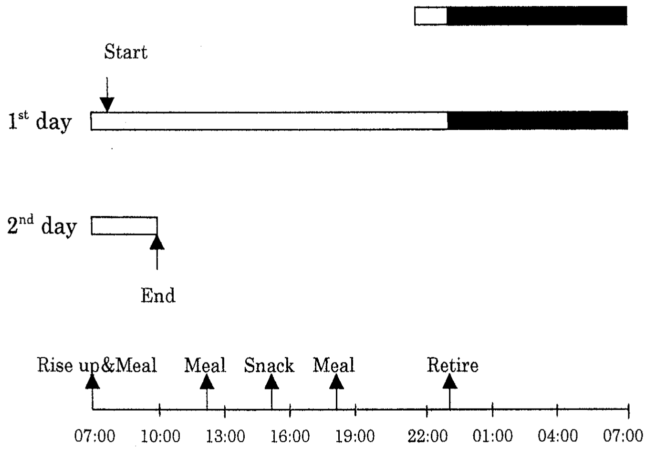

Fig. 1 Experimental schedule

Experimental protocol

The experiments were conducted under natural conditions in a building facing to the east. The participants entered a room at 19:00, wearing a cotton T-shirt and short pants, and inserted rectal thermistor sensors. Then they retired at 23:00 and rose at 07:00. They slept in a wood bed being covered by thin cotton bed cover. The recordings started at 08:00 and continued until 10:00 on the following day. The participants were directed to rise at 07:00 and retired at 23:00. Standardized meals were served at 07:00, 12:00, 18:00 and a snack at 15:30. During the experiment, the participants sat quiet in a sofa, in the housetop (20 m^2) and were allowed to read, write and listen to soft music during the daytime, but not to take a nap. Then, they are asked to spend time in a bedroom (20 m^2) after dinner until the next breakfast. The experimental schedule is shown in Fig. 1.

Data analysis

T_{re} and skin temperatures data were used for analysis from 10:00 on the first day to 10:00 on the second day.

For T_{re}, the maximum, minimum, amplitude and acrophase of circadian oscillation were estimated by best-fitting cosine curve analysis (Honma et al., 1989).

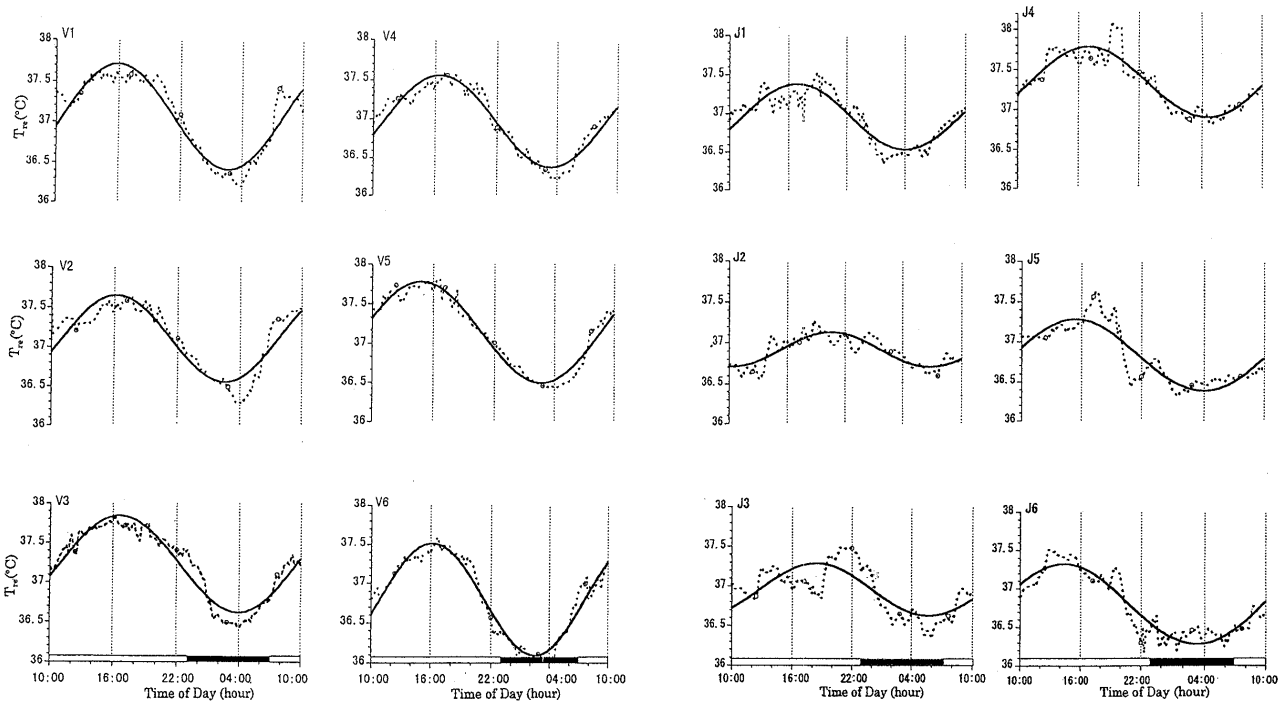

Fig. 2 The individual best-fitting cosine curves of circadian rhythms in T_{re} with six Vietnamese (V1-V6) and six Japanese (J1-J6) participants. Full line: best-fitting curves. Dotted line: raw rectal temperature curves.

Table 1. A comparison of best fitting cosinor curves applied for rectal temperature data between the Vietnamese and the Japanese subjects

	Maximum (°C)	Minimum (°C)	Range of oscillation (°C)	Acrophase (clock time, h)	Mesor (°C)
Vietnamese	37.68 ± 0.05	36.42 ± 0.07	1.26 ± 0.04	15.3 ± 0.23	37.06 ± 0.18
Japanese	37.36 ± 0.09	36.57 ± 0.09	0.78 ± 0.08	15.5 ± 0.23	36.96 ± 0.11
t-test	p<0.05	p<0.1	p<0.01	NS	p<0.01

values are mean ± SEM.

The statistical significance of differences in T_{re} and skin temperatures between Vietnamese and Japanese were analyzed by a two-way analysis of variance with repeated measures, separately for the waking and sleep periods.

The significance of differences in mesor, maximum, minimum, range of oscillation and acrophase were tested by Student's unpaired t-tests.

Results and Discussion

The individual best-fitting cosinor curves of circadian rhythms in T_{re} for the six Vietnamese (V1-V6) and six Japanese (J1-J6) are shown in Fig. 2. All the Vietnamese group showed the highest T_{re} over 37.5°C, while five out of six Japanese participants showed T_{re} below 37.4°C (peak point on cosinor curve of T_{re}). Four out of six Vietnamese group showed the lowest T_{re} below 36.5°C (V1, V2, V4 and V6). By contrast, there were only two Japanese participants who showed values below 36.5°C (J5 and J6). It should be noticed that the actual T_{re} curves and cosinor curves fit very well in the Vietnamese, while they don't seem to fit closely in the Japanese.

Table 1 compared several parameters including maximum, minimum, a range of oscillation, acrophase and mesor between the Vietnamese and Japanese, which were calculated from best fitting curves applied for raw data of T_{re}. Average maximum value was significantly higher in the Vietnamese than in the Japanese ($p<0.05$), while average minimum value tended to be lower in the Vietnamese ($p<0.1$). A range of oscilation defined from maximum and minimum values was 1.26 ± 0.04°C and 0.78 ± 0.08°C in the Vietnamese and Japanese, respectively, being significantly greater in the Vietnamese ($p<0.01$). Mesor value in the Vietnamese was 37.06 ± 0.18°C, which was significantly higher than that in the Japanese, 39.96 ± 0.11°C ($p<0.01$). Acrophase occurred around 15.3 h, not differing between the two groups.

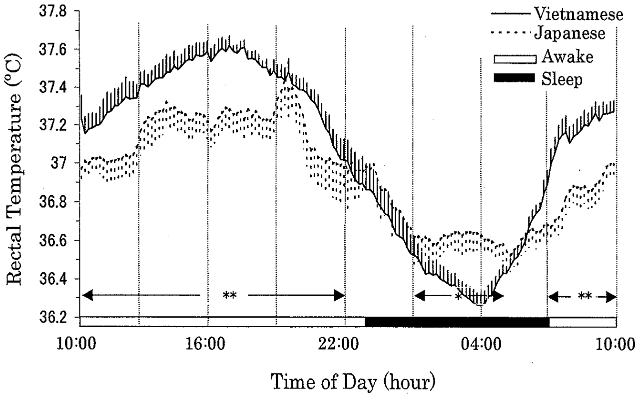

Fig. 3 A comparison of the average of T_{re} rhythms between Vietnamese and Japanese groups. Shaded area: SEM (n=6), * p<0.05, ** p<0.01.

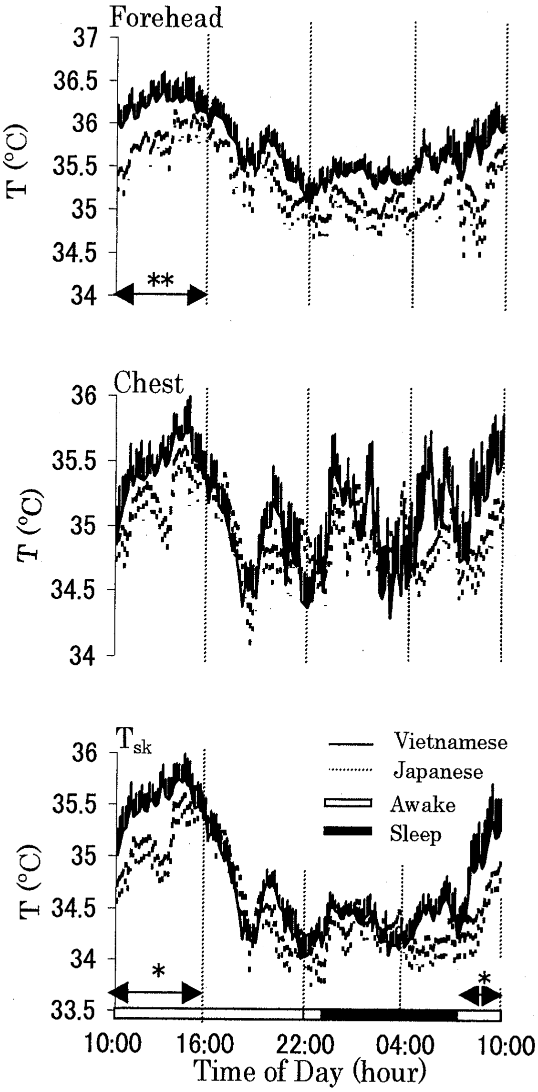

Fig. 4 A comparison of the average T_{sk} and skin temperature of the forehead and chest between Vietnamese and Japanese subjects. Shaded area: SEM (n=6).

Fig. 3 compared the circadian rhythms of the average rectal temperature curves between the Vietnamese and Japanese. The values during the daytime were significantly higher in the Vietnamese from 10:00 to 22:00 ($p<0.01$), while they were significantly lower in the Vietnamese during the nighttime, from 01:00 to 05:00 ($p<0.05$). On the following day the values were again significantly higher in the Vietnamese from 07:00 to 10:00 ($p<0.01$). The discrepancy between minimum values obtained from cosinor curves and those in actual curves might have been due to limited numbers of subjects.

What physiological mechanisms might be responsible for the clear finding that T_{re} was higher during the daytime and lower in the night in the Vietnamese?

Judging from the raw data in Fig. 3, the T_{re} in the Vietnamese group did not show a failure of temperature regulation, but rather constancy at higher levels during the daytime and at lower levels during the nighttime. This suggests that the setpoint of the core temperature was set at a higher level in the Vietnamese during the daytime. The higher core temperature accompanying heat acclimatization has often been reported in the literature (Davy, 1850; Sundstroem, 1927; Mason, 1940; Renbourn, 1946; Cisse et al., 1991; Ladell, 1964). The raised level of core temperature might be ecologically helpful for the reduction in the amount of sweating (Li and Tokura, 1996). What physiological mechanisms are responsible for more increased values of core temperature during the daytime in the Vietnamese remains unsolved.

What is the reason for the lower level of the core temperature at night in the Vietnamese than the Japanese? One possible interpretation is that the Vietnamese participants were repeatedly exposed to brighter illumination during the daytime than the Japanese. The monthly average total radiation sunlight from May to September (collected from 1980 to 1990) in Vietnam is 13.2 kcal/cm^2 (Hydrometeorological Agency, 1990), while in Japan is 11.9 kcal/cm^2, collected from 1974 to 1990 (Chronological Scientific Tables, 2001). There exists a significant difference in total sunlight radiation ($p<0.05$). If people are exposed to bright light during the daytime rather than to dim light, the nocturnal rise of melatonin is greater (Park and Tokura, 1999; Hashimoto et al., 1997), which might be responsible for the lower core temperature (Cagnacci, 1992). Due to technical failure, the melatonin data were not collected in our present experiment. However, we speculate that the chronic exposure to higher light intensity during the daytime might have raised the nocturnal level of melatonin. This speculation mentioned remains to be tested.

Lower body temperature at night could induce better

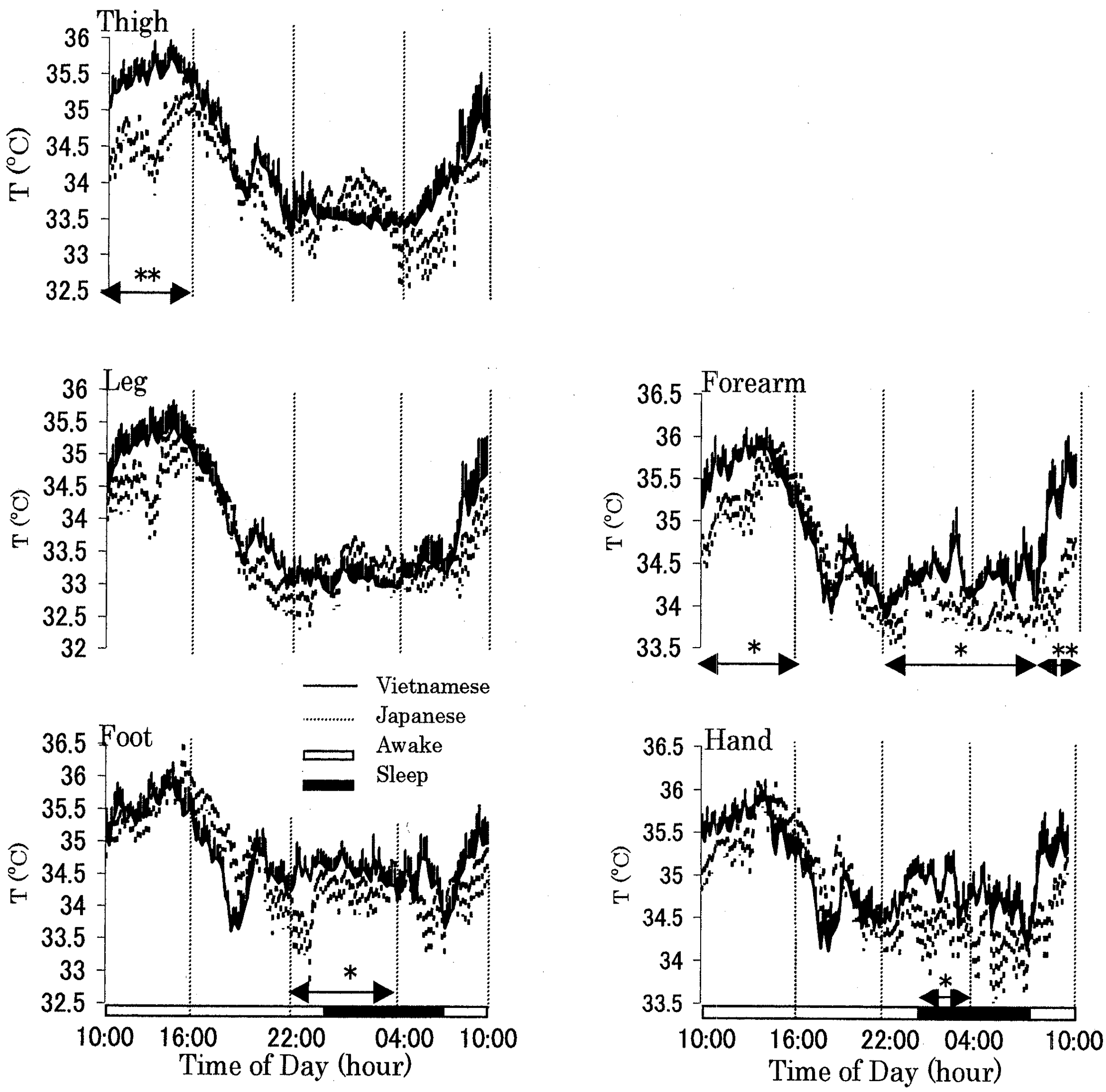

Fig. 5 A comparison of the average peripheral skin temperatures of thigh, leg, foot, forearm and hand between Vietnamese and Japanese group. Shaded area: SEM (n=6).

sleep (Monroe, 1967; Park and Tokura, 1999; Wakamura and Tokura, 2000), indicating adaptation to heat (Edholm et al., 1973; Li and Tokura, 1996).

Comparison of average T_{sk} and skin temperatures of the forehead, chest and extremities such as thigh, leg, foot, forearm and hand between the Vietnamese and the Japanese participants are showed in Figs. 4 and 5. As seen in Fig. 4, T_{sk} and skin temperatures at forehead and chest were clearly higher during the daytime than those at night in both groups. Skin temperatures at thigh, leg, foot, forearm and hand were higher during the daytime than those at night. This is the opposite of the well-established facts that these temperatures are lower during the daytime than at night (Aschoof and Heise, 1972). It is supposed that the average high ambient temperature of 34.6°C may be responsible for the opposite finding in Vietnam. Increased limb skin temperatures during the daytime would be physiological reactions to warm T_a, which are advantageous for dissipation of body heat. Skin temperatures of extremities seemed to start falling gradually around 15:00 (Fig. 5). Sweating rate which could be greater in the late afternoon than in the forenoon (Hildebrandt, 1974) might be responsible for these declines of limbs kin temperatures. T_a dropped from the average highest of 36 ± 0.4°C during the daytime to 33 ± 0.5°C with approach of the evening, which might have induced the vasoconstriction in the extremities. The main reason why the opposite pattern of the skin temperatures of extremities was observed in both groups in Vietnam might be that the skin vessels in the extremities reacted, having resulted in inhibition of excessive increase of core temperature under the influence of considerably high air temperature.

Skin temperatures at forehead, thigh, forearm are significantly higher during the daytime in Vietnamese than in Japanese (p<0.01 and p<0.05) (Figs. 4 and 5). It is possible that being exposed to continuous warmth for a long term might set a higher level of skin temperature for effective heat dissipation or for avoidance of heat penetration from surrounding in the Vietnamese group than the Japanese group. According to our unpublished data, the sweating rate was significantly lower in the Vietnamese than the Japanese in response to identical warm stimulation (43°C water immersion of legs) and forearm skin temperature was significantly higher in the Vietnamese. The Vietnamese seemed to be acclimatized to warm temperature mainly via activity of peripheral vasomotion, the role of wet heat loss being not so great. The reduced amounts of sweat in the Vietnamese might have play a role for increased level of core temperature, compared with those in the Japanese.

Also, skin temperatures at extremities such as foot, forearm and hand were significantly higher at night in the Vietnamese than in the Japanese (p<0.05) (Fig. 5). Higher skin temperature at extremities is beneficial for lower T_{re} (Aschoof and Heise, 1972), reflecting warm acclimatization.

Apart from these, some genetic component might be involved in the different physiological responses between Vietnamese and Japanese. However, it should be noticed that the climate in which man lives and his activity levels play greater role in acclimatization than do differences in morphology (Wyndham, 1966). In our present experiment, judging from the values of RI and BMI in the Vietnamese and the Japanese, the physical constitution does not seem to be responsible for different levels of core temperature between the Vietnamese and the Japanese.

It is concluded that the Vietnamese group had higher core temperature during the daytime and lower one at night than did the Japanese group, resulting in greater range of oscilation in the core temperature rhythm and the skin temperatures were also higher in the Vietnamese group.

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