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Studies on Heat Adaptation (Report II)

—Sweating responses of tropical inhabitant—

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Abstract: For analysis of "Heat Adaptation" process, the sweating reaction of the chest skin during immersion of the lower limbs under 43°C circulating water for half an hour was studied on 2 subjects using thermography in an environmental control chamber (28°C, 60%). One was a Burmese male recently arrived in Japan (subject Y). The other was a Chinese subject stayed 8 years here (subject H). The time lag before onset of sweating was 13.08 minutes after heat load application in the first subject and merely 6.15 minute in the second subject. The initial oral temperature and skin temperature were found to be significantly lower in subject Y compared with subject H. The long term heat acclimatization process in contrast to short term heat acclimatization was discussed in this paper.

Key words: Sweating response, Heat acclimatization, Tropical inhabitant, Local heat load, Thermography

Previously, the sweating reaction of a tropical inhabitant had been reported. While the lower limbs were immersed in circulating hot water at 43°C for half an hour, we studied the thermal responses of the subject namely the skin temperature on the chest paired with changes in oral temperature; the detailed methodology had been published before (Kosaka *et al.*, 1980). The subject showed a noticeably prolong latency of onset of sweating compared to that of a Japanese volunteer under the same heat stress (Ohwatari *et al.*, 1983). In the same setting, we had done experiments on two subjects in November. One was a Burmese male who had arrived in Japan recently and another was a Chinese who had stayed here for 8 years now. The physical characteristics of the subjects were given in Table 1.

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Table 1. The physical characteristics of the subjects

subject	sex	age (yr)	height (cm)	weight (kg)	duration in Japan	BSA (m^2)	skin fold thickness (mm)			
							biceps	triceps	subscapular	suprailiac
Y	M	36	147	50	2 months	1.49	4.8	6.0	11.0	9.0
H	M	33	185	78	8 yrs.	2.02	4.8	6.8	17.0	9.1

Y = Burmese
H = Chinese

The changes in oral temperature continuously monitored using a thermister and the changes in skin temperature of chest derived from thermography were shown in Fig. 1.

Fig. 1 showed the oral temperature changes of the two subjects on the upper part and the skin temperature changes in the lower portion.

1. In subject Y the initial oral temperature before the heat load was 36.60 ±0.04°C. It was 36.71±0.02°C in subject H. The difference between the mean oral temperature of the two subjects was found to be statistically significant ($P<0.001$).
2. The oral temperature began to rise after the heat load with a period of latency i.e. 8.9 minutes after heat load in subject Y and 5.4 minutes after heat load in subject H.

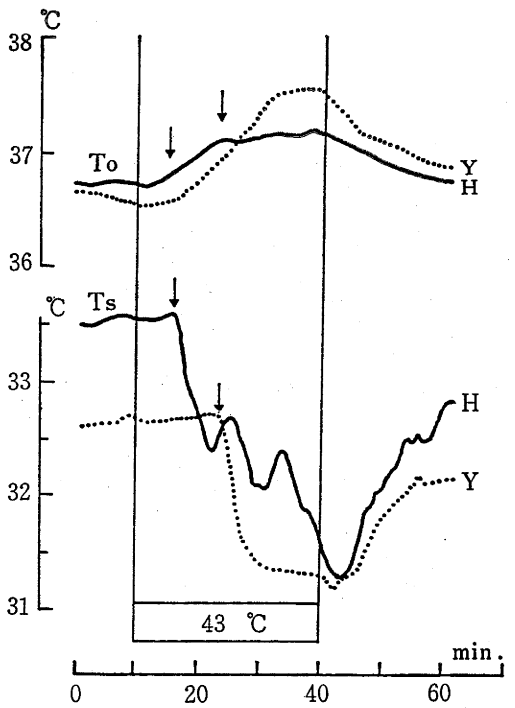

Fig. 1. The changes in oral temperature and skin temperature of chest
To: oral temperature
Ts: skin temperature

3. The rise in oral temperature had 2 slopes in both subjects. The first slope was steep and second slope was more or less flat. In subject Y, the rate of rise was 0.06°C/min in former slope and 0.01°C/min in the latter. For subject H it was 0.04°C/min and 0.01°C/min, respectively.
4. The skin temperature of chest derived from thermography were found to be initially 32.63±0.04°C (Y) and 33.56±0.02°C (H), respectively. The difference between the mean skin temperature of the two subjects were found to be statistically significant ($P<0.001$).
5. Sweating on the chest started with a latency period of 13.08 minutes after application

Table 2. Climatic data of subjects' native land

	RANGOON	TAIPEI	NAGASAKI
Mean air temp. in a yr. (°C)	27.3	22.1	16.6
Precipitation in a yr. (mm)	2,530	2,100	2,002
Humidity (%)	74	83	74

Rika-nenpyo by Maruzen Co. (1984)

of heat load in subject Y. It started barely 6.2 minutes after heat load in subject H. Suffix is to say that subject Y was only 2 months here at the time of experiment and subject H, a Chinese doctor, had stayed 8 years here. In case of Japan native (subject J), he sweated instantly without additional heat load in the same environmental setting (Ohwatari *et al.*, 1983). The prevailing environmental conditions of comparable data of each subject's native place and that of Japan (Nagasaki area) were given in Table 2.

Kuno (1956) suggested that the natives in the torrid zones have the capacity to sweat but they have acquired the ability to avoid excessive sweating by acclimatization. In sett'ers in less than 3 years, the sweat reflex is simi'ar to that of new comers. It has been suggested that more than 6 years of residence in the tropics is necessary to acquire the same capacity as the natives (Morimoto, 1978). In this series of experiments, it was evident that the lag of sweating after heat load was in the decreasing order of subject Y>H>J.

The long term acclimatization in contrast to short term acclimatization is enigmatic except to the teleologic thinking which can't be ruled out as incorrect in this instance. Hori (1977) studied the sweating responses in atheletic and non-atheletic subjects subjected to heat load and physical training. He found that sweating reaction in summer was characterized by a lower salt concentration in sweat in spite of higher sweat rate. He suggested that difference in the effectiveness of sweating for cooling the body could be considered a possible cause of smaller sweat volume and smaller rise in rectal temperature for athletes. He pointed out that in heat acclimatized subjects there were better utilization of the skin surface wetted, lower salt concentration in sweat and superior capacity for heat dissipation without sweating. New comers to the tropical zones after a period of acclimatization will acquire the additional capacity for cutaneous vasodilatation and the capacity for an *earlier* onset and maintenance of sweating (Hardy, 1980).

On the other hand, tropical people, under heat load will show a profoundly different response regarding sweating as we have reported here. Kawahata (1950) suggested that the number of active sweat glands of an individual became established at about 2 years of age. Among the ethnic groups, there is a gradient in the number of active sweat glands

increasing from the north to the equator. Immigrants between these zones failed to conform to this gradient when they immigrated after the age of two (Kawahata, 1950). But Collins (1965) reported that Weiner did not find any difference in sweat gland densities in Europeans, Bantu and Indians. Also there are reports that said there was little (Gibson *et al.*, 1948) or no difference (Herrman *et al.*, 1952) between the sweating ability of the White and Negro races.

Hori *et al.*, (1977) reported the anthropometric data, body temperature and basal metabolic rate in Thai subjects compared to Japanese people and had concluded that the body shape in Thai people is considered to be more convenient to heat dissipation in hot environment. No doubt that the functional, behavioural and anthropometric characteristics of tropical people are tuned to an increase in their capacity of homeostasis in hot environment.

The various level at which the acclimatization process takes place may be (1) central, together with numerous input/output; (2) neuroglandular junction (with attendant modification); and (3) end-organ level, particularly the sweat glands and skin.

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暑熱順化に関する研究（第2報）ー熱帯地住民の発汗反応ー

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暑熱適応の形成過程を解析する目的で，人工気象室（温度：28°C，湿度60%）中で，皮膚局所加温刺激ーヒトの両側下肢を43°C の循環温水に30分間浸水負荷ーによって誘発される前胸部発汗反応をサーモグラフィ装置を使って観察した．

被験者Y（ビルマ人・男性）は実験の2ヶ月前に来日，被験者H（中国人・男性）はすでに8年間の長きに亘って日本に滞在していた。被験者Yにおいては，加温負荷後発汗開始までの潜時は13.08分を記録，一方，被験者Hのそれは 6.15分であった．被験者Yの初期口腔温と初期前胸皮膚温は共に被験者Hのそれらの値に比較して有意な低値を示した．これらの結果から，短期間の暑熱順化に対比して長期間の暑熱順化に関する討論が加えられた．

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