

# Relationship between the Duration of Stay in Japan of Malaysian Subjects and the Suppression of Sweat Gland Sensitivity by Iontophoretically Applied Acetylcholine

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**Tropical African and Thai Subjects regulate core temperature with less amount of sweat against heat compared to temperate Japanese subjects. Reduced sweating in tropical subjects was attributed to suppression of both central and peripheral sudomotor mechanisms. The objective of the study is to compare the local sweating response activated by acetylcholine (ACh) applied iontophoretically among the Malaysians (n=12) of varying duration of stay in Japan.**

Based on their length of stay, Malaysian subjects were divided into 2 groups, MS (n=6) with a duration of stay of 3 to 15 months and ML (n=6) with 27 to 60 months. ACh, the primary transmitter for sudomotor innervation, was iontophoretically administered on the forearm. Sweating response elicited directly (DIR) and indirectly via axon reflex (AXR) were evaluated by quantitative sudomotor axon reflex test. Although the sweat onset time was tend to reduce with longer duration of stay among Malaysian subjects, there was no significant difference among the two groups. AXR(1), sweat volume elicited by axon reflex for 0-5 min was  $0.96 \pm 0.11$  mg/cm<sup>2</sup> in MS and  $1.40 \pm 0.23$  mg/cm<sup>2</sup> in ML. AXR (2), that for 6-11 min, was  $1.09 \pm 0.13$  mg/cm<sup>2</sup> and  $1.45 \pm 0.20$  mg/cm<sup>2</sup>. DIR, sweat volume directly induced by ACh for 6-11 min, was  $3.40 \pm 0.18$  mg/cm<sup>2</sup> and  $3.96 \pm 0.24$  mg/cm<sup>2</sup> in MS and ML, respectively. A slight positive correlation between DIR and the duration of stay in Japan was observed in Malaysian subjects, though not significant (p=0.14). From these results, suppressed neuroglandular response to ACh was confirmed in Malaysians. It is suggested that long-term heat-acclimatization acquired in tropical subjects may decay after immigration to temperate area.

**Key words:** long-term heat-acclimatization, deacclimatization, sweating response to ACh, Malaysian

## Introduction

Acclimatization to ambient heat through thermoregulatory mechanism of sweating is man's adaptive response when exposed to extremely hot conditions. Sweating is a mechanism of heat dissipation for humans when exposed to a hot environment. It is known that sweating response to heat is influenced by climatic condition. In an area where there is a distinct seasonal fluctuation of ambient temperature like Japan, various physiological responses may change season by season. As to sweat responses to seasonal changes during summer, the sweat rate is higher, with a shorter latent period for sweat onset and lower salt concentration in sweat than in winter<sup>1,2,3</sup>. It is generally accepted that tropical natives having acclimatized to heat for a long time begin to sweat more slowly than temperate natives and the salt concentration in sweat in the former is much lower than in the latter<sup>1,2,3,4,5,6</sup>.

Heat-tolerance is achieved by the lowering of threshold for sweating and enhanced sweating in short-term acclimation<sup>7,8</sup>. On the contrary, tropical inhabitants show heat-tolerance with suppressed sweating<sup>1,8,9,10,11</sup>. Adaptation to temporary exposure to heat and acclimatization to tropical climate by permanent residents were distinguishable from each other<sup>1</sup>. The thermotolerance with suppressed sweating and enhanced dry heat loss is more predominant than that with enhanced sweating which is seen in short-term heat acclimatization from the view points of body fluid maintenance and osmoregulation<sup>10,11</sup>.

The natives in torrid zone have the capacity to sweat but have acquired an ability to avoid excessive

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sweating by acclimatization<sup>1)</sup>. For settlers of less than 3 years, the sweat reflex is similar to that of newcomers. It has been suggested that more than 6 years of residence in the tropics is necessary to acquire the same capacity as the natives<sup>1)</sup>.

An upward shift of threshold core temperature for sweating and decrease in acetylcholine (ACh) - sensitivity of the sweat glands were reported in Thai subjects. It has been suggested that sudomotor mechanisms is down-regulated both centrally and peripherally in tropical natives<sup>11)</sup>. In this study to clarify the deacclimatization process of heat-acclimatized tropical subjects through residence in temperate zone, local sweating response activated by ACh applied iontophoretically was compared between the Malaysians staying in Japan for a certain period of time under a thermoneutral condition.

## Materials and Methods

### Subjects

Experimental subjects were 12 sedentary Malaysian students, who came from Malaysia for studies in Nagasaki University between, 20 - 39 years of age with similar physical activity levels. Duration of stay in Japan of those varied from 3 to 60 months. Based on the length of stay in Japan, they were divided into 2 groups, MS (n=6) with a duration of stay of 3 - 15 months and ML (n=6) with 27 - 60 months. Malaysia (1° 7' N, 100° 120' E) is located in a tropical zone with dry and wet-seasons with minimal seasonal variations. Annual mean ambient temperature is 26.7°C and relative humidity is 81%. Nagasaki (32° 44' N, 129° 52' E) is located in a temperate zone with hot summer and cold winters; 16.7°C and 72% relative humidity.

The subjects gave informed consent after having been acquainted with the potential risks associated with experimental procedures. We paid great attention to the subjects in accordance with Helsinki Declaration of 1975.

### Measurements and procedures

The experiment was carried out in a controlled climatic chamber at  $26 \pm 0.5^\circ\text{C}$  with relative humidity of  $60 \pm 3\%$  and less than 1 m/sec air velocity at 2-5 p.m.. Prior to the test, subjects were dressed lightly and were rested in the climatic chamber for 60 minutes. Sweating rates were recorded from forearm in each subject. Quantitative sudomotor axon reflex test, QSART<sup>10,12,13,14)</sup> was performed to quantitatively evalu-

ate glandular ACh-sensitivity. The QSART capsule separates three compartments of concentric circle. ACh put in the outer compartment for sweat induced. The direct response (DIR) is measured in this compartment from 6th minute after measurement start, and an axon reflex response (AXR) is measured in central compartment during the experiment except of changing to another QSART capsule for one minute. In figure 1, AXR (1) were measured before changing to another QSART capsule and AXR (2) were measured after that. The sweating were induced by 10% ACh (Ovisot, Daiichi Pharmaceutical Co., Ltd., Japan) solution, and electric current of 1 to 2 mA supplied for 5 minutes. A dry nitrogen gas flowed in the capsule at 0.3 L/min of flow rate. Sweating rates were measured with hygrometer-ventilated capsule method<sup>9)</sup> (H211, Technol Seven, Co., Ltd., Japan) and data save and analysis were used by a computer (PC 9801, NEC, Japan)

### Statistical analysis

All data were expressed as means  $\pm$  SEM. Statistical significance was determined by unpaired Student's t-test for comparison between MS and ML for repeated measures at the  $p < 0.05$  level.

## Results

The physical characteristics of the two groups of subjects were tabulated in Table 1. There was no significant difference observed in age, height and weight among the two groups. Typical recording of a single subject is shown in Fig. 1. When ACh was applied iontophoretically, AXR sweating occurred after a latent period (sweat onset-time) and reached a plateau phase within a few minutes. At the end of iontophoresis, DIR sweating became sustained, while AXR(2) sweating declined to the baseline during the observation.

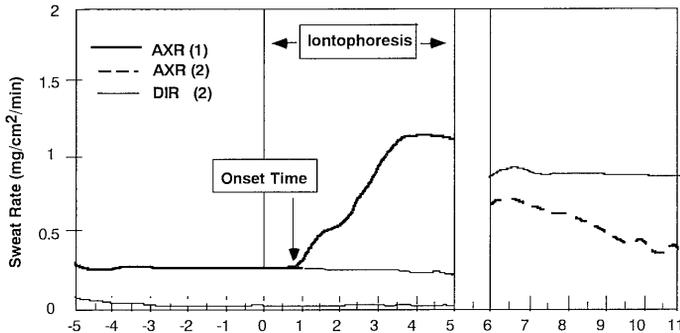
There was no significant difference observed in sweat onset time among the two groups, MS ( $1.89 \pm 0.11$  min) and ML ( $1.65 \pm 0.15$  min)(Fig.2). The AXR(1), AXR(2) and DIR in MS were 31%, 25% and 14% respectively lower than ML. There was no significant difference. (Fig. 3, 4, 5).

Relationship between DIR and the duration of stay in Japan in MS and ML were shown in Fig. 6. Although it was not significant ( $p = 0.14$ ), there is a slight positive correlation.

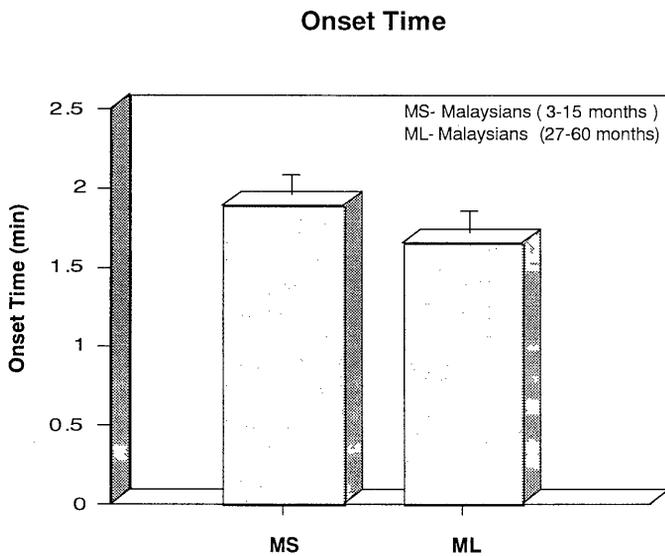
**Table 1.** Physical characteristics of the subjects

	n	Age(years)	Height(cm)	Weight(kg)
MS ( 3-15 Months)	6	24.5±2.2	162.8±2.5	58.09±3.09
ML (27-60 Months)	6	22.8±0.3	159.2±2.8	55.20±2.46

Values are mean ±SEM No. Significant.



**Fig. 1.** Typical recording of AXR(1), AXR(2) and DIR sweating in a Malaysian student. Iontophoresis of 10% ACh was performed with 2 mA of direct current for 5 min. Just after the cessation of current loading, the sweat capsules were exchanged each other, then sweating rate recordings were continued for another 5 min. Sweat onset-time was 1.00 min. Sweat volume was 2.99 mg/cm<sup>2</sup>, 3.12 mg/cm<sup>2</sup> and 5.54 mg/cm<sup>2</sup> on AXR(1), AXR(2) and DIR respectively.

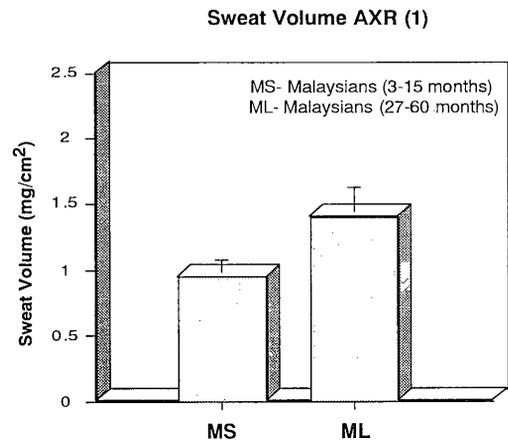


**Fig. 2.** Comparison of the sweat onset-time between Malaysian students with different durations of stay in Japan. Values are mean±SEM. No significant.

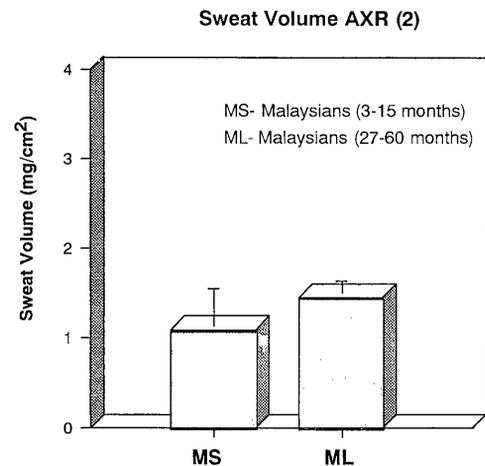
**Discussion**

The subjects coming from Malaysia are expected to be more acclimatized to heat compared to those living in Nagasaki, which is located in a temperate zone.

This study seeks to clarify whether heat-acclimatized tropical subjects lose their nature of acclimatization



**Fig. 3.** Comparison of AXR(1), axon reflex-mediated sweat volume for 0-5 min, among Malaysians with different durations of stay in Japan. Values are mean±SEM No significant.

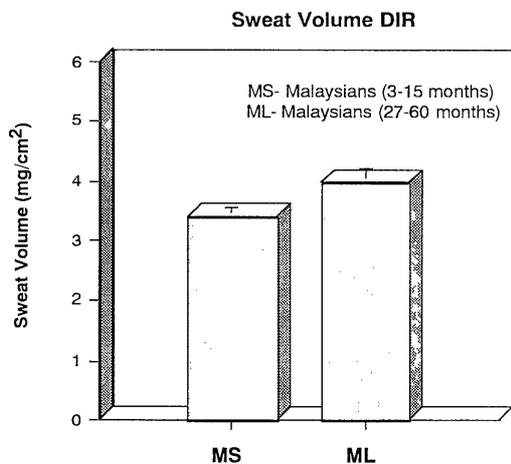


**Fig. 4.** Comparison of AXR(2), axon reflex-mediated sweat volume for 6-11 min, among Malaysians with different durations of stay in Japan. Values are mean ±SEM No significant.

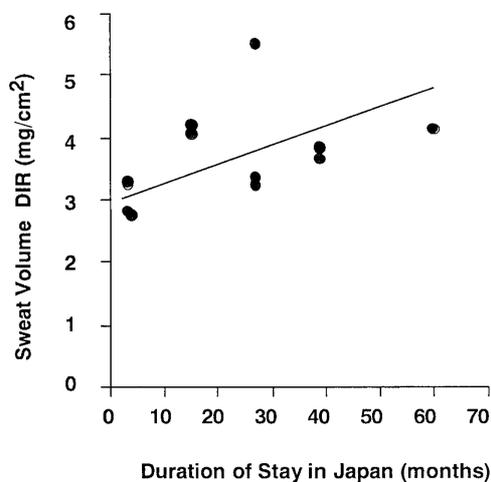
through residence in a temperate area. ACh-sensitivity of the sweat glands was evaluated by QSART.

Suppression of sweating response to ACh applied iontophoretically has been shown in Thai and tropical Africans<sup>10,11</sup>. It was previously shown that Japanese subjects had shorter sweat onset time compared to that of African subjects and the AXR(1), AXR(2) and DIR sweat volumes of the Japanese were greater than the Africans<sup>10</sup>. In this study we showed suppressed sweating response to ACh in Malaysians and the AXR(1), AXR(2) and DIR in MS were less than that of ML. We also observed that the sweat onset-time among ML was shorter than MS, though the differences were not significant (p=0.15).

Heat-tolerance is achieved by the lowering of



**Fig. 5.** Comparison of DIR, directly activated sweat volume for 6-11 min, among Malaysians with different durations of stay in Japan. Values are mean  $\pm$ SEM. No significant.



**Fig. 6.** The relationship between DIR and the duration of stay in Japan in MS and ML. No significant correlation ( $r=0.533$ ,  $p=0.14$ )

threshold for sweating and enhanced sweating in short-term acclimation<sup>7,8</sup>). During acclimation through daily exercise in a hot environment, these thermoregulatory changes are about three-quarters developed by the end of the first week of exposure and is generally thought to be complete after 10-14 day s<sup>16</sup>). Heat acclimation is transient and gradually disappears if not maintained by repeated heat exposure. It is believed that heat acclimation might be retained for 2 weeks after the last heat exposure but then be rapidly lost during the next 2 weeks<sup>17</sup>).

According to our knowledge, this is the first report showing deacclimatization process of heat-acclimatized tropical subjects through residence in a temperate area. DIR sweating of Malaysian subjects showed a

slight positive correlation with duration of stay in Japan, though not significant ( $p=0.14$ ). It might indicate that long-term heat-acclimatization acquired in tropical subject who was born and raised in a tropical area decays after immigration to a temperate area. It is suggested that long-term heat-acclimatization is, at least in part, a phenotypic phenomenon.

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