COLD ACCLIMATIZATION

By

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Acclimatization to cold can be induced in laboratory animals and can be demonstrated by increase in survival time in severe cold, with diminution of the incidence of cold injury as compared with control animals. In human beings knowledge about heat debt, relative importance of core and shell temperature during acclimatization is not definite. Similarly it is not known if altitude affects the temperature regulation.

From logistic point of view, it is essential to find out a regime which can induce a substantial cold acclimatization in large number of troops in a reasonable period of four to six weeks. Lastly it is essential to know if the cold acclimatization so acquired will overlast the intervening summer months.

OBJECTS

These studies were undertaken to find out :—

(a) Criteria of evidence of cold acclimatization in human beings.

(b) Effect of altitude on cold acclimatization.

(c) Method of inducing cold acclimatization.

(d) Effect of intervening summer on cold acclimatization.

MATERIALS AND METHODS

For elucidating criteria of evidence of cold acclimatization it was decided to compare the reaction of cold of the following 3 batches of subjects :—

(a) 8 Tibetans who had genetic and racial acclimatization. This batch will be referred as 'Locals'.

(b) 8 Jat subjects who were living in subzero conditions for over two years. This batch will be referred as 'Acclimatized.'

(c) 8 Jat subjects who had no previous experience of cold. This will be referred as 'Unacclimatized.'

All the 3 batches after stabilisation in comfortable ambient temperature were exposed to O°C for period of 60 minutes. The following observations were made at the onset, thirty and sixty minutes after exposure :—

(a) Oxygen consumption was determined by measuring inspired air with a dry gas meter for 5 minutes and analysing expired gas for Oxygen content in a Beckman Oxygen analyser.

(b) Shivering was measured by using a portable integrating Offner EEG/EMG type machine, with the electrodes placed on the anterior aspect of the thighs and abdomen.

(c) Skin temperatures were measured by 9 different areas by means of copper constantan thermocouples and Brown potentiometer.

(d) Rectal temperature was measured with a thermistor connected to a portable tele-thermometer.

To find out the effect of altitude the reactions of exposure to O°C of an acclimatized group were compared at sea level and at 13,000 feet.

To find out the method of inducing cold acclimatization sixteen unacclimatized subjects were exposed for three hours daily to temperature varying from +2°C to +5°C. These subjects were wearing Angola Shirt, flannel trousers, cap comforter and combat boot with woollen socks. During exposure they were not allowed any physical activity. At the onset and after each week their reactions to O°C exposure for 60 minutes were measured for a total period of 4 weeks.

The effect of intervening summer on cold acclimatization is still under study. A batch of 16 subjects who had been artificially given cold acclimatization at the onset of winter will be studied at intervals of 3 months for the whole year.

RESULTS

Figures 1 to 5 show the oxygen consumption, total amount of shivering in millivolt, skin temperature, threshold for shivering, weighted skin temperature and

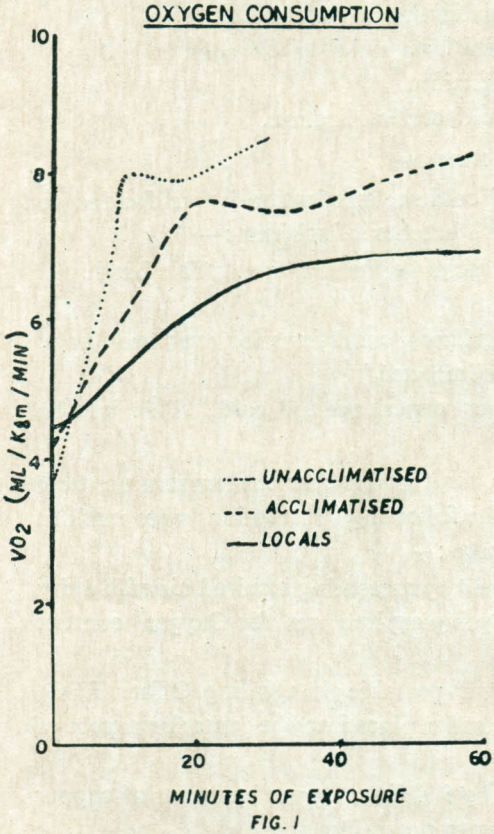


FIG. 1

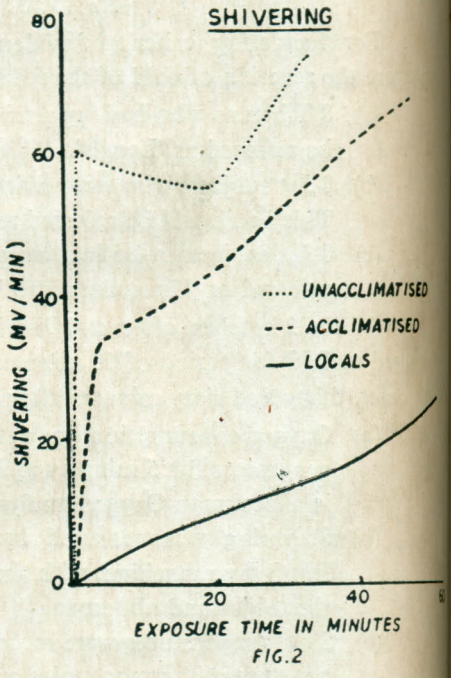


FIG. 2

rectal temperature of the 'Locals', Acclimatized and non-acclimatizedsubjects. It will be noted that non-acclimatized subjects could not complete sixty minutes of

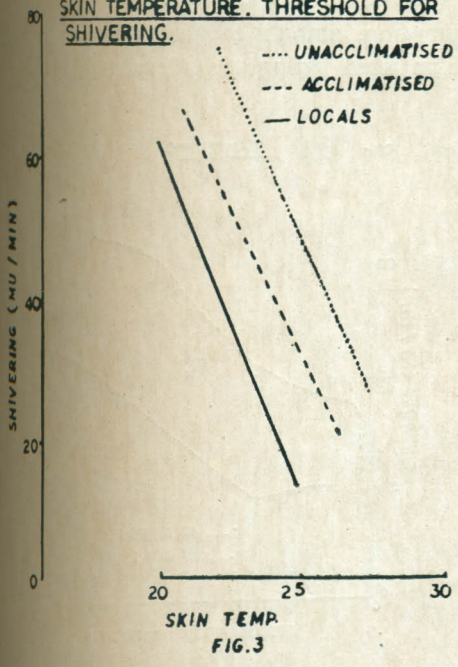


FIG. 3

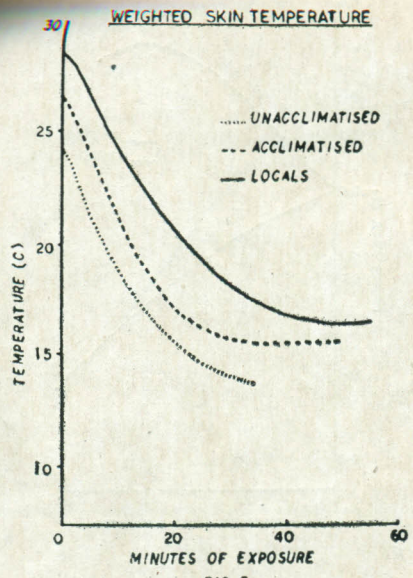


FIG. 5

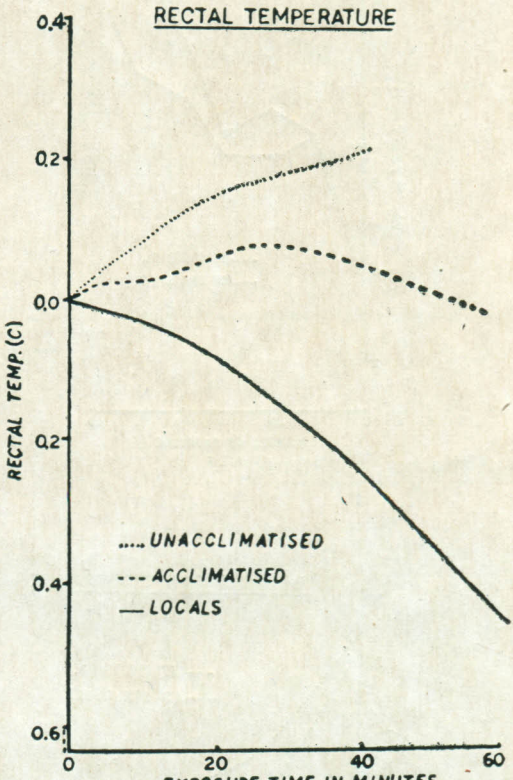


FIG. 4

exposure. Their oxygen consumption, total amount of shivering, rate and degree of fall in skin temperature were maximum, while the locals formed the other limit of

minimum, the acclimatized subjects falling in between the two. As regards the rectal temperature, greatest fall is seen in acclimatized subjects, minimum in non-acclimatized ones while the acclimatized ones fall in between the two.

Figures 6 to 9 show the oxygen consumption, amount of shivering, weighted skin temperature, rectal temperature in acclimatized group at sea level and at the

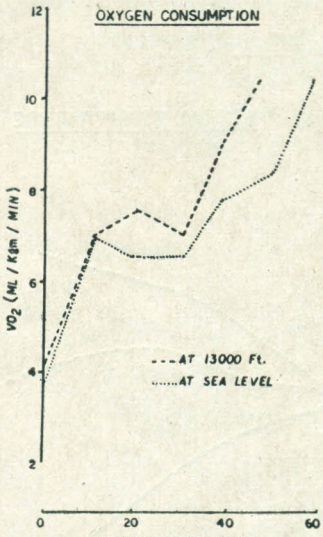


FIG. 6

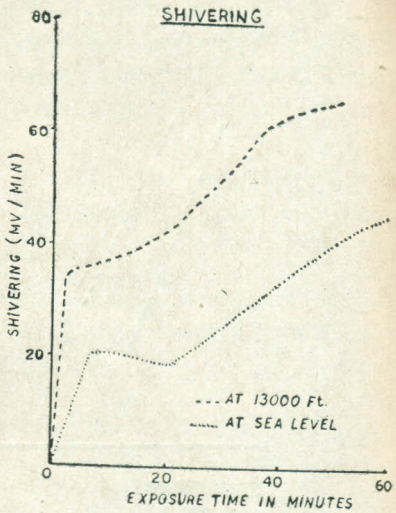


FIG. 7

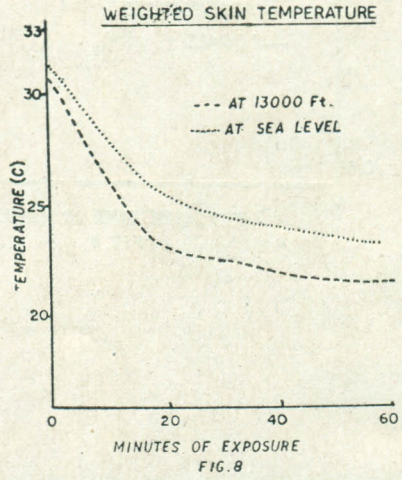


FIG. 8

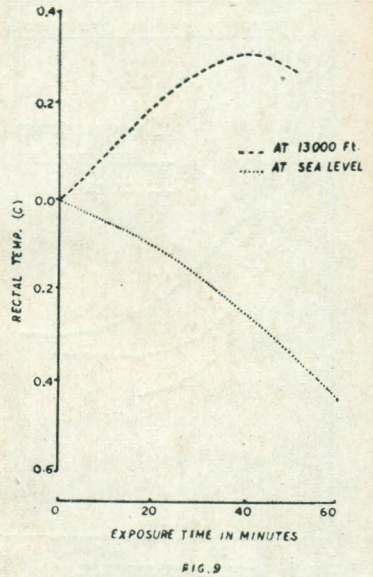


FIG. 9

altitude of 13,000 feet. It will be noted that altitude has increased the oxygen consumption, amount of shivering, rate of fall of skin temperature and decreased fall in rectal temperature.

Figure 10 shows the weekly variation in oxygen consumption, skin and rectal temperature, and amount of shivering in the group of unacclimatized subjects being

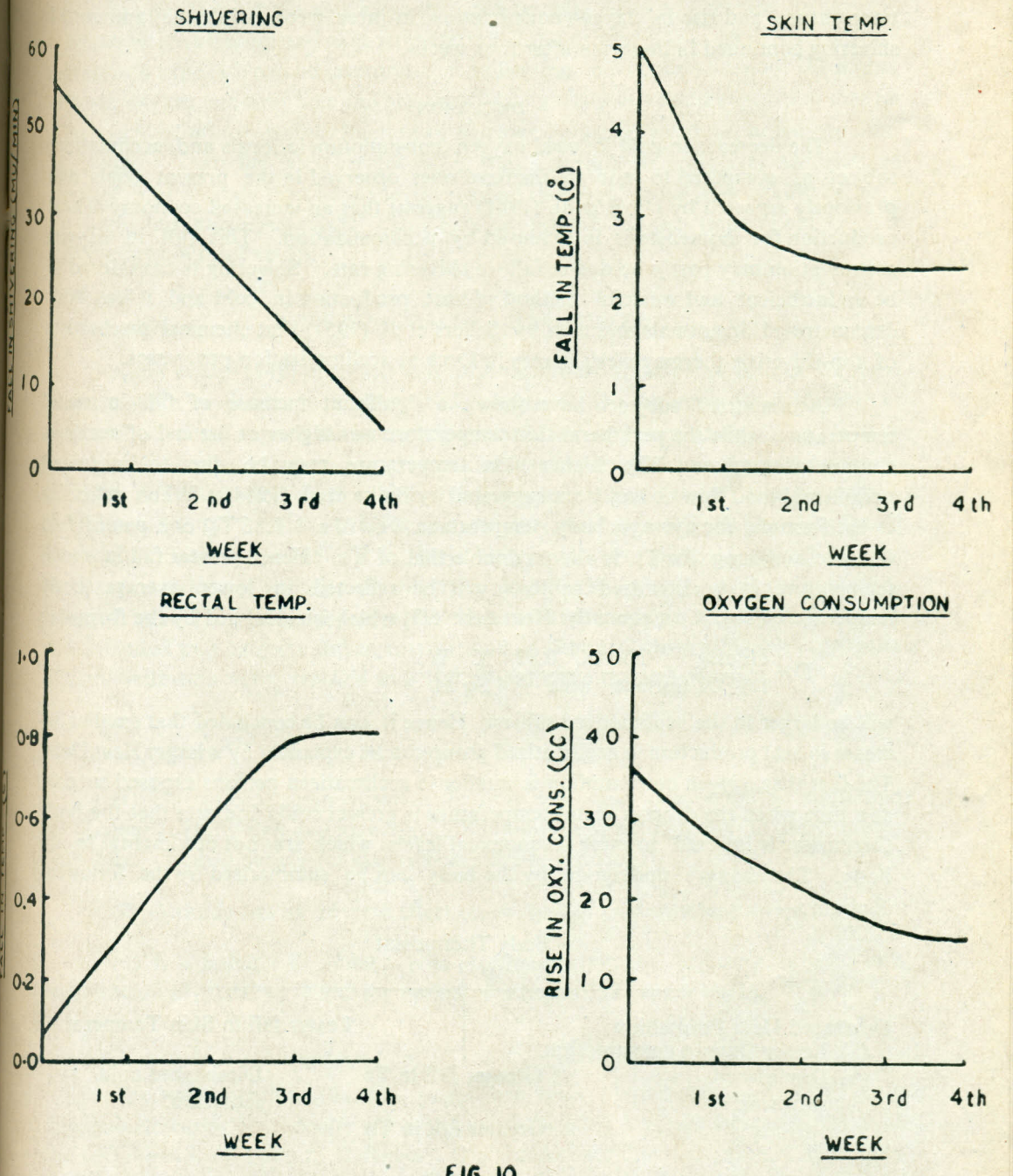


FIG. 10

exposed three hours every day to cold for induction of cold acclimatization. It will be seen that fall in skin temperature became static after two weeks, fall in rectal temperature and rise in oxygen consumption in three weeks while the amount of shivering continued falling even after four weeks.

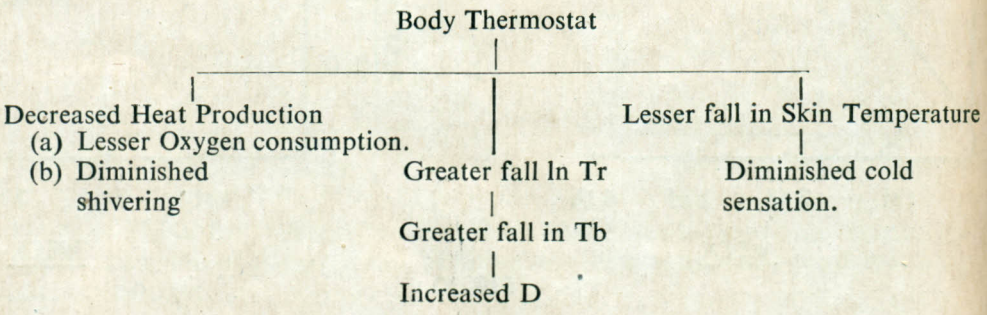
DISCUSSION

The decrease in cold induced oxygen consumption in locals and acclimatized subjects as compared to non-acclimatized ones observed in the present trials and previously reported by Davis et al. (1961) suggests that an increased economy of heat production for homeostasis is achieved by acclimatization. This fall in oxygen consumption may partly be due to fall in shivering rate. Shivering is considered to be an inefficient and wasteful method of heat production in cold and it has been demonstrated in animals and men by Sellers et al. (1951) that chemical mechanism of non-shivering thermogenesis comes in force as acclimatization progresses.

Acclimatized subjects have shown a significant increase of fall in rectal temperature while the peripheral skin temperature was higher at the end of acclimatization programme. The higher skin temperature may be due to increased peripheral blood flow as has been suggested by Balke et al. (1944). When referring to the formula for average body temperature (0.64 Tr + 0.36 Ts) one would find that the weighing for Tr is almost double that of Ts. Hence greater fall in rectal temperature in acclimatized subjects will be reflected in lower average body temperature (Tb). Consequently Heat debt (D) which is calculated by the formula:

$$D = \frac{\text{Hourly} \quad \text{Tb} \times 0.83 \times \text{W}}{1.8 \times \text{Surface area} \quad 4 \text{ Sq M}}$$

will be larger in the acclimatized subject. Hence it can be concluded that smaller increase in heat production in acclimatized group can be explained by a larger Heat Debt. The fact that oxygen consumption is smaller in acclimatized persons exposed to cold at a time when the drop in rectal temperature is greater could indicate that the body thermostat is lowered to mere economical levels which are not detrimental to the body. The changes undergone by the body can be summarised by the following diagram :—



EFFECT OF ALTITUDE ON COLD ACCLIMATIZATION

On the basis of the above results it can be said that a decrease in Oxygen consumption, shivering and skin temperature and a greater fall in rectal temperature during cold exposure can be interpreted as indicating cold acclimatization. At higher altitude oxygen consumption and shivering were greatly increased suggesting that an impairment of non-shivering fraction of thermoregulatory mechanism had occurred at altitude. There has been greater fall in skin temperature and rectal temperature was higher at altitude than at sea level meaning thereby that subjects at altitude were not incurring much heat debt. This may be related to the impairment of cold acclimatization mechanism.

INDUCTION OF COLD ACCLIMATIZATION

Ames et al. (1948) observed that after repeated exposures to cold of the same subjects there was evidence of improved tolerance. On the other hand Horvath et al, (1947) who had carried out many experiments in low temperature chambers have been unable to obtain convincing evidence of acclimatization to cold. In our trials in which unacclimatized subjects were exposed partly dressed to a temperature varying from +2°C to +5°C for three hours everyday, positive evidence has been found that acclimatization can occur if subjects do not do any physical activity during exposure and there is stimulus of shivering present throughout. Oxygen consumption, fall in skin and rectal temperature became static within three weeks. As it was intended that subjects shiver, this parameter although decreasing with progress of acclimatization never reached to a static level up to the end of trial.

SUMMARY

(1) During cold acclimatisation there is less heat production as manifested by Oxygen consumption and shivering. Body develops the capacity to incur higher heat debt. Fall in peripheral skin temperature is reduced.

(2) Altitude has an adverse effect on process of cold acclimatization.

(3) It is possible to induce cold acclimatization by exposing subjects to a temperature of +2°C to +5°C for period of 3 hours daily for 3 weeks.

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