EFFECTS OF BEHAVIORAL THERMOREGULATION ON DYNAMIC THERMAL RESPONSES

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INTRODUCTION

Effects of the way of wearing clothes on physiological responses have been a subject of a behavioral regulation. Much of the earlier researches, however, involves physiological acclimatization produced by continous long-term exposure to cold environment. Since acclimatization is a continuum of many small counter balanced changes, acute physiological response in a dynamic mode would give tlie complementary information along with steady-state physiological responses(1). Most workers in a cold storage room experience changing environmental conditions, for esample, moving from a cold working environment to a warm pause room within a time scale of 5 - 30mins(2). It has been also pointed out that there has been comparatively little research regarding the negative effect on comfort under moderately cold conditions where small differences in thermal response due to behavioral thermoregulation would not be masked due to severe environment.

Jeong and Tokura(3) disclosed that esposing the extremities of the sedentary subject wearing a single layer of garments to the cool environment(10 "***C)*** induce a rise in core temperature. More considerations are necessary for the moderately cold room workers in the following aspects: 1) cooler but dynamic working conditions 2) possibility of wearing additional clothing items. Therefore the objective of this paper is to examine tlie following questions:1) Are there any short-term physiological changes throughout the wearing phases as seen in Fig. 1 in the moderately cold but dynamic working conditions (20 "C -5 "***C*** -20 "C) compared with the previous paper(3)? 2) What is the effect of insulating items over a short innenvear when tlie total clothing weight of the four kinds of clothing ensemble is controlled to be the same each other as shown in Fig.2?

MATERIALS AND METHODS

Eight healthy male subjects, aged 18-25 years, were dressed in eight different types of clothes, i.e. combinations of innenvear (100 % cotton double knit, long or short type), outerwear(PET/COT 65/35, twill) and insulation items such as hood, vest, hat, gloves or socks (100% cotton, knit). Total insulation value was estimated by program *cloman* version 3.04 (Loten, W.A. & Havenitli, G., 1992) for tlie tested ensemble. It was ranged from 0.3 clo for the short innerwear(S) to 1.0 clo for the

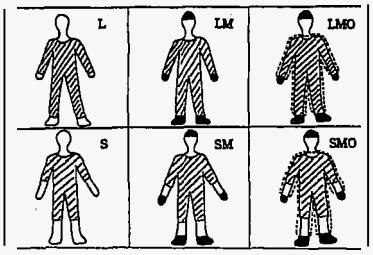

Fig. 1. Esperimental clothing for the test throughout wearing phases .

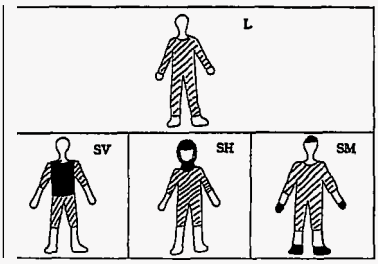

Fig .2. Esperimental clothing for the test of effects of the various items. (Condition: equal clothing weight)

most insulating assembly (LMO). The weight difference between long and short underwear was matched to a vest(V) or hood(H) or gloves-socks-hato, so that the total clothing weight of L, SV, SH or SM was controlled to be the same. Environmental chamber I was adjusted to 20 "C, G0 ±5% RH, 0.14 m/sec and adjoining chamber II was set at **5** "C, G0 ±5% RH, 0.2m/sec as a cold room. Rectal temperature was measured every 2-3 mins during the test protocol, which is rest (20mins, 20 °C)-rest (20 mins, **5** "C)-exercise(15 mins, **5** "C , moderate work load using a bicycle ergometer)-rest(20 mins, **20** "C). Skin temperature data collected using T-type thermocouples connected to a data logger every min. Mean skin temperature of 10 sites were calculated (4). Blood pressure, heart rate and subjective voting were measured. All esperinient were conducted according to the randomized complete block design.

RESULTS

1.Effects of extremity exposure throughout the wearing phases **on** rectal temperature: Rectal temperature was relatively kept higher in short innerwear(S) than in long innerwear(L) under the normal room temperature. Rectal temperature of S, however, becomes equal to that of L in the moderately cold condition(Fig.3). If the subjects wore gloves, socks, and hat with short innerwear, exposing only forearm and calf(SM), rectal temperature was maintained to be higher than LM both in 20 "C and 5 "C chamber at rest state(Fig.4). Additive wearing of outerwear over the long and short innerwear with miscellaneous insulating items diminishes the effects of extremity exposure on rectal temperature, hence, the rectal temperature of LMO was higher than that of SMO throughout the esperiment.

2. Effects **of** the insulating items with equal clothing **weight** : The rectal temperature in the case of L was kept to be the lowest both in 20 °C and **5** "C chamber at rest state. Higher rectal temperature in the case of short underwear with miscellaneous items on extremities(SM) or hood(SH) indicates that vasoconstriction is still occurring at the esposed forearm and calf(Fig.5).

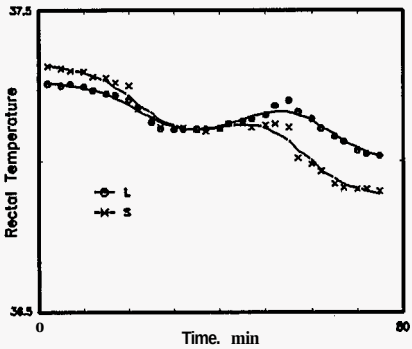

Fig. 3. Effects of estremity exposure (S vs. L) on rectal temperature.

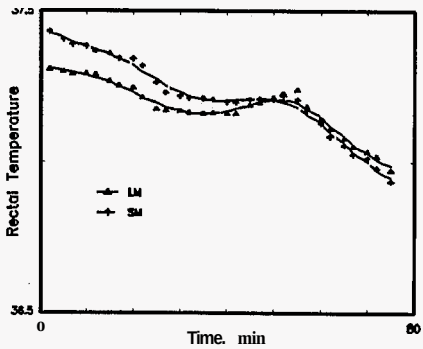

Fig. 4. Effects of forearm and calf esposure (SM vs. LM) on rectal temperature.

Moreover, heat loss from extreme peripherals and the head is reduced due to the covering of those parts. It is also noted that in the moderately cold conditions the rectal temperature of short innerwear with vest(SV) was statistically the same as that of long innerwear, i.e. under tlie condition of controlled total clothing weight, covering tlie torso with vest over short innerwear was not enough to keep the rectal temperature higher than long innenvear. However, rectal temperature of SM was statistically higher than that of SV or L.

3.Changes in rectal temperature in dynamic conditions: The changes in rectal temperature were different depending on the kind of thermal load. Rectal temperature decreased more steeply for the case of exposed extremities (S, SV, SM) than L when the subjects moved from the condition of 20 "C to **5** "C. When the subjects exercised in the cold room, however, the rectal temperature showed slower increase in the case of S, SV and, SM than L or SH. When subjects entered 20 °C chaniber after exercise in the cold room, rectal temperature of S, SV, SM decreased sharply compared with that of L.

4. Skin temperature & other responses : Generally, the mean skin temperature of SV and SM was the highest excluding the case of wearing outerwear(table 1), eventhough the rectal temperature of SV and that of SM were in the different range as stated earlier. Especially, at 20 "C chamber, during the beginning 20 mins of the experiment, pulse and dia. blood pressure of SM were higher than that of SV. Psychologically, SM at the initial 20 "C was felt warmer than SV. **As** for the skin lemperature of the extremities, skin temperature of upperarm and thigh was noteworthy. Upper arm and thigh skin temperature of SM or SV were higher than that of L, eventhough forearm and calf are exposed and vasoconstriction is still effective in the exposed area. Slight compensation effect was found at the tip of finger and toe. Skin temperature of toe and fingertip in the case of S was higher than other clothes.

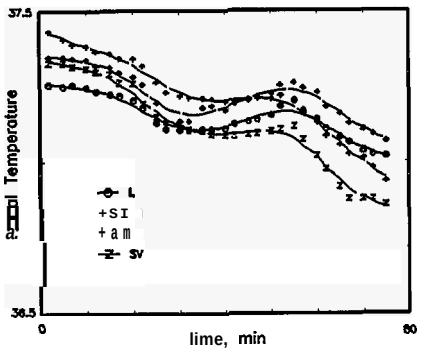

Fig. 5. Effects of the distrubution of the clothing items with the equal clothing weight.

Table 1. Means of weighted mean skin temperaure at 5 "C conditions.

5 °C rest		5 °C esercise	
Means	Clothes	Means	Clothes
27.68 a	SMO	25.68 a	SMO
27.38 a	LMO	25.56 a	LMO
26.44 b	SM	21.42 b	SV
26.42 b	SV	24.31 b	SM
26.40 b	LM	24.11 c	LM
26.01 c	L	23.53 d	SH
25.92 c	SH	23.21 e	L
25.18 d	S	23.18 e	S

* means with the same letters are significantly different

CONCLUSION

A rise in rectal temperature due to short-tern1 esposure of the extremities in S was observed only for limited temperature range. Esposing forearm and calf only (SM) was more effective than S at 5 "C. Rectal temperature of SM was higher than LM even in 5 "C , which reflects that both vasoconstriction at the exposed area and reduced heat loss from hand and feet seemed to be beneficiary at this temperature. Wearing a short innerwear with hood (SH) induced a relatively high and stable rectal temperature throughout the dynamic changes in environmental temperature **and** work load, which is a relatively different response compared with other clothing ensemble. Further study on the effect of esposing extremities on physiological response is necessary across the wider range of temperature.

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