

The influence of two weeks of microclimate cooling on the state of heat acclimatization

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SYNOPSIS

Five volunteer Black subjects were acclimatized according to the climatic-room acclimatization procedure, and their states of heat acclimatization were determined by the usual heat-stress test. The subjects thereafter wore pre-frozen jackets in a somewhat higher environmental temperature (33,9/35,6°C), stepping at the same rate as before for four hours a day for fourteen days. The heat-stress test was repeated and followed by a similar test at the higher environmental temperature.

It was found that fourteen days of microclimate cooling in a very hot environment had no adverse effect on the degree of heat acclimatization. The sweat rates during microclimate cooling remained high, even though no sweating is possible beneath the pre-frozen ice-jacket, which indicates that there is an increase in sweat rate from the areas of exposed skin.

SAMEVATTING

Vyf swart proefpersone is eers geakklimatiseer volgens die klimaatskamer akklimatiseringsprosedure voordat hul aan die gewone hittedruktoets blootgestel was om die mate van hul akklimatisasie te bepaal. Daarna het die proefpersone voorafbevrore baadjies gedra by 'n ietwat hoër omgewingstemperatuur (33,9/35,6°C) terwyl hulle teen dieselfde tempo as tevore vir vier ure per dag vir veertien dae stapoefeninge gedoen het. Die hittedruktoets was herhaal en gevolg deur 'n soortgelyke toets by die hoër omgewingstemperatuur.

Dit was gevind dat veertien dae van mikroklimate verkoeling in 'n warm omgewing geen nadelige gevolg op die mate van hitte-akklimatisering gehad het nie. Sweetvermoë gedurende mikroklimate verkoeling het steeds hoog gebly alhoewel dit nie moontlik is om onder die bevrore baadjie te sweet nie. Dit dui daarop dat daar 'n verhoging van sweetvermoë van die ontblote veldele moes plaasgevind het.

INTRODUCTION

A loss of heat acclimatization accompanying the use of microclimate suits could present a problem if the suits were used constantly in hot environments. A previous study¹ reported no loss of acclimatization in a group of 24 men who wore pre-frozen ice-jackets for a period of four weeks in a hot underground environment. However, several factors could have contributed to this finding; namely, the fact that the men wore the jackets for three hours, whereas these suits are really effective for only 2½ hours (30 minutes of heat stress) and, secondly, the jackets were prototypes and the water bags tended to leak. This leaking decreased the effective period of cooling provided by the suits, and probably caused the men to be subjected to heat stress for more than 30 minutes in each three-hour period. The possible influence of microclimate cooling on the state of heat acclimatization has therefore been re-examined.

METHODS

Five volunteers, who were fully acclimatized according to the climatic-room procedure (Group 1),

and who had the physical characteristics shown in Table I, were used for this study. Their state of acclimatization was assessed by the usual laboratory procedure², namely, four hours of stepping at 35 W in a climatic room set at 32,2°C (W.B.)/33,9°C (D.B.) and an air speed of 0,4 m/s. The usual physiological observations were made every hour. Thereafter, for a period of two weeks, the men worked at the same rate while wearing pre-frozen ice-jackets at 33,9°C (W.B.)/35,6°C (D.B.).

The following two days served as test days to determine whether any loss of heat acclimatization occurred. On the first day, the state of acclimatization of the subjects was again assessed by the usual laboratory procedure. On the second test day, the subjects were required to step without jackets in the hotter environment of 33,9°C (W.B.)/35,6°C (D.B.), and the same measurements were made. For purposes of comparison, the results obtained from another group of subjects

TABLE I
PHYSICAL CHARACTERISTICS

GROUP 1	Subject	Age y	Height m	Weight, kg		
				Before accl.	After accl.	Last test
	1	18	1,646	67,75	69,45	71,00
	2	18	1,678	60,05	60,85	62,20
	3	19	1,726	59,05	62,90	64,30
	4	21	1,652	57,25	57,90	58,90
	5	18	1,529	44,75	48,65	50,15
	Mean			57,77	59,95	61,31
GROUP 2						
	1	21	1,626	57,20	60,30	
	2	25	1,654	59,30	62,85	
	3	22	1,725	57,38	62,15	
	4	20	1,622	52,30	54,65	
	5	28	1,689	55,80	58,55	
	Mean			56,44	59,70	

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(Group 2) were used to assess the data obtained on the present groups at the more severe conditions of 33,9°C (W.B.)/35,6°C (D.B.).

RESULTS

For ease of reference, the following code will be used in the discussion of the results:

Condition	Test day	Test Environment, °C
1	Post-acclimatization	32,2/33,9
2	Loss after microclimate cooling	32,2/33,9
3	Loss after microclimate cooling	33,9/35,6
4	Post-acclimatization (independent group)	33,9/35,6

The average results obtained under conditions 1 and 2 are given in Fig. 1 and Table II, while those for conditions 3 and 4 are also shown in Table II.

Friedman two-way analyses of variance were used to test whether conditions 1 and 2 differed signifi-

cantly with respect to hourly heart rates, rectal temperatures, and sweat rates. Where the analysis indicated that there were significant differences between conditions, a Student's *t*-test based on paired differences was used to determine which group was responsible for the difference. Mann-Whitney tests³ were used to show

whether there were significant differences between conditions 3 and 4 with respect to the parameters measured.

The third-hour sweat rate for condition 2 could be shown to be significantly higher than that for condition 1 at the 5 per cent level

of significance. No differences between other parameters for conditions 1 and 2 could be shown to exist at the 5 per cent level.

The only significant difference found between conditions 3 and 4 was in heart-rate response during the third and fourth hours, which for condition 3 was higher than that for condition 4.

DISCUSSION

In all previous studies on the loss of acclimatization over a seven- to fourteen-day period^{4,5}, significant increases in heart rate and body temperature were reported. Cooling by means of microclimate suits has been shown to reduce climatic work stress to the levels observed during exposure at room temperature⁶. It was therefore expected that the wearing of microclimate suits for two weeks would result in a detectable or even significant loss in the state of heat acclimatization. Although the finding that virtually no such loss occurred is in agreement with that previously reported¹, it still remains a surprising result.

A possible reason for no real loss in acclimatization can be found in the physiological responses of the subjects during microclimate cooling (Fig. 2). While wearing microclimate suits, the men worked in a more severe environment than they did during the heat-stress test. The subjects' heart rates, rectal temperatures, and total sweat rates when they were wearing the suits and working at identical rates, were very similar to those observed after they had been acclimatized. In general, average fourth-hour body temperatures remained at about 38,0°C, the same average as during the heat-stress test. Average fourth-hour heart rates varied between 120 and 130 beats per minute, as against the average of 129 beats per minute for fully acclimatized men. The most unexpected finding was the high total sweat rate observed on men wearing the microclimate suits. Sweat production beneath the ice-jackets is well-nigh impossible because skin temperatures below the ice-jackets have been found to be still below 30°C after two hours of wearing the jackets. All the sweat must therefore be produced by the

TABLE II
MEAN VALUES OF CONDITIONS 1 TO 4

Variable	Time	Conditions				Differences	
		1	2	3	4	3-4	
		N=5	N=5	N=5	N=5		P
Heart rate (beat/min)	1	114,4	114,4	141,8	133,4	8,4	> .10
	2	118,4	116,4	151,6	134,8	16,8	> .05
	3	125,6	119,2	154,0	133,4	20,6	< .05
	4	128,8	125,6	162,0	135,6	26,4	< .01
Rectal temp. (°C)	1	37,60	37,74	38,14	38,22	-0,08	> .10
	2	37,80	37,82	38,40	38,60	-0,20	> .10
	3	37,98	37,88	38,66	38,64	0,02	> .10
	4	38,04	37,96	38,82	38,79	0,03	> .10
Sweat rate (g/h)	1	400	430	756	1075	-319	> .10
	2	568	482	1110	1032,5	77,5	> .10
	3	402	526	733	564	169	> .10
	4	397	380	460	355	105	> .10

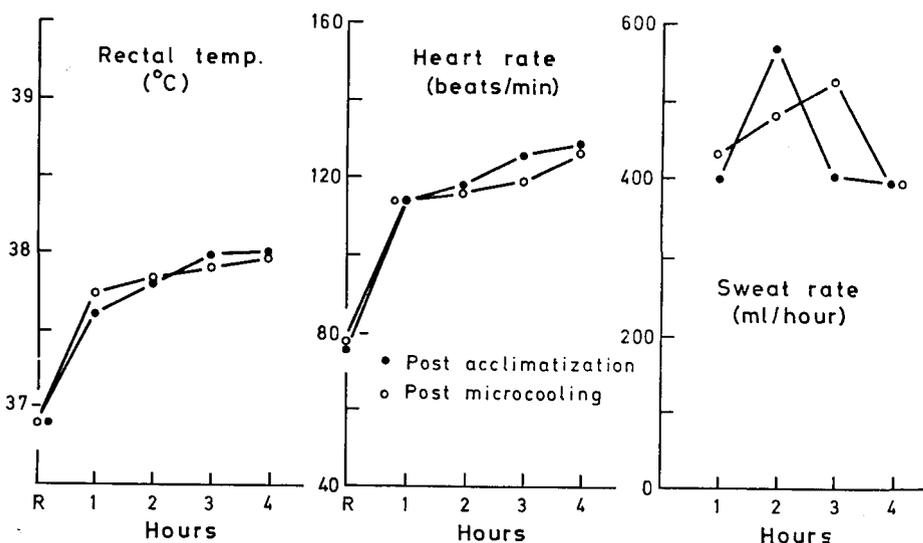


Fig. 1—Average response to heat stress after two weeks each of acclimatization and microclimate cooling

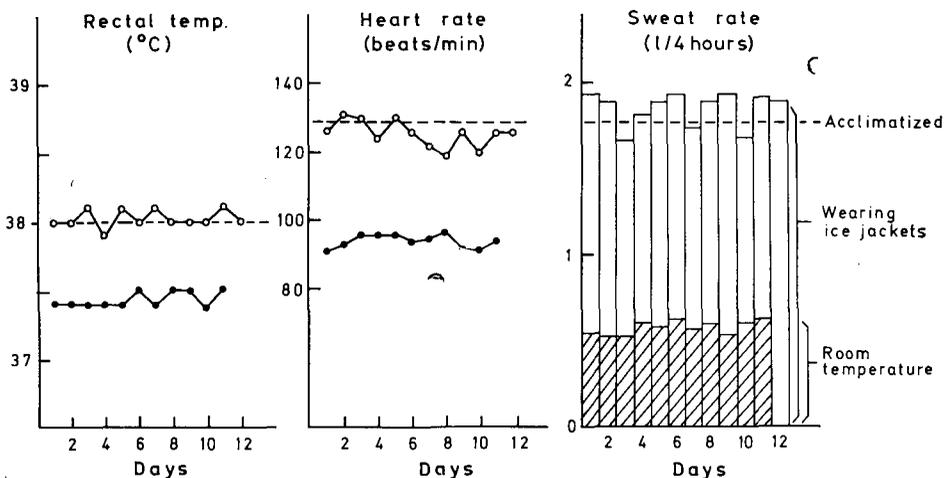


Fig. 2—Fourth-hour rectal temperatures and heart rates, and total sweat rates, during microclimate cooling and while working at room temperature, in comparison with values obtained after climatic-room acclimatization

areas not covered by the cool suit (arms, head, neck, hips, and legs), and the rate of sweat production in these areas must be greatly increased. The interaction between the areas of high and low skin temperature, sweat rate, and control over body temperature during this type of microclimate cooling certainly calls for further investigation.

Another interesting observation was the difference between the sweat-rate responses during the heat-stress tests before and after microclimate cooling. Although there was no significant difference in total sweat rate, a significant increase in the third-hour sweat rate was observed after microclimate cooling. As shown in Fig. 1, maximum sweat production occurred during the third hour, and not during the second hour as is usually observed in fully-

acclimatized men⁷.

Even if no significant loss in the degree of acclimatization occurs in men who wear microclimate suits, the question still arises: what would happen if men who are used to working with microclimate protection in an environment of 33,9°C W.B. should suddenly find themselves without such protection? The answer is to be found in Table II. Although the average heart rates after microclimate cooling tend to be higher than those observed prior to such cooling, no significant differences in body temperature or sweat rates were detected. After two weeks of microclimate cooling, the men were still as well protected by their state of heat acclimatization as they were immediately after completing the usual climatic-room acclimatization procedure.

The weight gain of Blacks during heat acclimatization, which was reported previously⁸, again showed up very prominently in this study (Table I). The subjects gained 2 to 3 kg during the first month, and an additional 1,4 kg during the second month of their contract period.

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