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[Following is the translation of an article by N. I. Bobrov entitled "O Termoregulyatsii v Organisme Cheloveka v Usloviyakh Zapolyar'ya" (English version above) in Gigiyena i Sanitariya (Hygiene and Sanitation), Vol. 25, No. 7, Moscow, July 1960, pages 26-30.]

From the Chair of Naval Hygiene of the Military-Medical Order of Lenin Academy imeni S. M. Kirov

The task of the present work was to study the temperature changes of the skin and the heat flow under the continuous action of cold on the organism in daily activity in the Transpolar region. The solution to this problem, as well as the study of basal metabolism and heat production, was dictated by the necessity of clarifying the question of thermoregulatory changes originating during the adaptation of the organism of the investigated individuals to the low temperatures of the outside air. Studies conducted previously in the Transpolar region were devoted mainly to the study of the basal metabolism, heat production and other functions of the organism in individuals who had worked for long periods under the aforementioned conditions (I. P. Baychenko, A. D. Slonim and associates, V. A. Yakovenko, N. I. Bobrov, I. S. Kandror, etc.). The changes taking place in the physical thermoregulatory activity in individuals who had been continuously subjected to the cold, were studied principally under laboratory conditions (M. Ye. Marshak, N. I. Bobrov, B. B. Koyranskiy, I. M. Bogachev, Kramer and Shul'tse, etc.). Considering the importance of this problem in the solution of practical problems connected with increasing the work capacity of individuals residing in the Transpolar region, we carried out the present study.

Observations were carried out on 130 individuals

who served in various capacities in the Transpolar region. According to their length of service under these conditions, these individuals were divided as follows: up to one year -- 42, from one to two years -- 34, over two years -- 54 individuals. The ages of the men investigated were between 20 and 25. All 130 individuals were in good health, as per medical conclusion. In order to elicit the changes in the skin temperature and heat flow, all individuals were subjected to a functional cooling test, which consisted of a single chilling of the upper and lower extremities in 5° water for 30 minutes. The skin temperature on the cooled areas of the body was recorded by means of thermocouples, and the heat flow was measured by means of the S. Ya. Zarzhevskiy calorimeter. The functional cooling test was conducted in a specially assigned chamber with an optimum temperature-humidity regime (air temperature 19 to 20°, relative humidity 50 to 60 percent).

The data on changes in the skin temperature of the upper extremities during cooling are cited in Table 1.

In a considerable number of individuals with a brief length of service in the Transpolar region the skin temperature of the upper extremities decreased under cooling six to eight degrees, and in a few the decrease was 9-11°. From the anamnesis we managed to ascertain that 10 men who manifested only a slight decrease of skin temperature on the cooled areas had worked, prior to their arrival in the Transpolar region, outdoors in the northwest and northern regions of the Soviet Union in the capacities of fishermen, lumberjacks, railroad-coach couplers, drivers, etc., for no less than two years. In the majority of individuals with a work record of one to two years in the Transpolar region, the skin temperature of the cooled areas (upper extremities) decreased during the same period of time to 9 to 11°. In a small number of specialists in this group, who have been engaged principally as machinists, electricians, or motormen, the skin temperature of the same areas decreased toward the end of cooling to six to eight degrees. And, finally, in the absolute majority of individuals with a work record of over two years in the Transpolar region, the skin temperature had decreased toward the end of cooling only to 11-13°. In this group there were 12 individuals in whom the skin temperature of the cooled areas never fell below 14-15°. They felt no cold whatever, despite the fact that their hands were immersed in 5° water. However, there were a few among these individuals in whom the skin temperature fell to eight degrees toward the end of cooling. All of them bear the

Table 1

Changes in the skin temperature of upper extremities upon cooling in 5° water

(1) Стаж работы в Заполярье	(3) Число обследованных лиц	(2) Процент лиц, у которых температура кожи верхних конечностей снизилась под влиянием охлаждения					
		(4) до 6—7°	до 7,1—8°	до 8,1—9°	до 9,1—10°	до 10,1—11°	(5) свыше 11°
(6) До 1 года . .	42	42,8	28,6	14,3	9,5	4,8	—
(7) От 1 года до 2 лет. . . .	34	11,8	5,9	47,0	23,5	11,8	—
(8) Свыше 2 лет	54	—	7,4	18,5	20,4	12,9	40,8

1 - Length of working time in the Transpolar region
2 - Percentage of individuals in whome the skin temperature of the upper extremities decreased under the effect of chilling
3 - Number of individuals investigated
4 - up to 6° to 7° ...up to ...up to
5 - over 11°
6 - up to one year
7 - from one to two years
8 - over two years

cold poorly, though they have been living in the Far North for over two years, for they are working in high-temperature quarters (machinists, motormen and compressormen).

An analogous picture was observed upon cooling the lower extremities, in all individuals.

Thus, on the basis of the results obtained we can conclude that as the period of work in the Transpolar region lengthens, the constrictions of peripheral vessels in response to the effect of cold become less intense. We were also interested in the question of periodic increases of temperature of the skin during cooling (the so-called Lewis wave).

The results of observations are shown in Table 2.

It is seen from Table 2 that in the majority of individuals (62 percent) who had worked in the Transpolar region less than a year, no fluctuation was elicited in the temperature curve upon cooling of the upper extremities. In a small number of individuals of this group (28.5 percent) the fluctuation of the temperature curve was only slightly noticeable. The amplitude of these fluctuations did not exceed 0.5 to 1°. In some representatives of this group, who had worked in the open air, mainly as fishermen, prior to arrival in the Transpolar region, the temperature curve fluctuations were clearly pronounced. The amplitude of fluctuations in these instances reached 2.5 to 3.5°.

Individuals who had worked in the Transpolar region from one to two years showed more or less marked fluctuations, reaching 3.5°. In individuals whose work is conducted in high-temperature quarters (boiler and engine rooms, etc.), no periodic fluctuations of the lumen of peripheral vessels of the upper extremities were observed. In individuals with a work record of over two years in the Transpolar region there were observed marked fluctuations, with amplitudes reaching five and even eight degrees. These people never complained of a disagreeable sensation of cold. On the contrary, they noted a sensation of a flow of warmth to the cooled areas of the body. In only a few individuals of this group were the fluctuations in the temperature curve completely absent. In these individuals the cooling action produced a rapid vascular spasm and severe pain in the upper extremities as a result of which we had to discontinue our observations temporarily. From the data obtained we can conclude that with the lengthening of the period of work in the Transpolar region, more frequent and more intense fluctuations of the lumen of peripheral vessels set in, in response to

Table 2

Changes in the temperature of the skin of the upper extremities upon cooling in 5° water

1 Стаж работы в Заполярье	2 Число обследованных лиц	3 Процент лиц, у которых обнаружены:		
		4 отсутствие флюктуаций в температурной кривой	5 очень заметные флюктуации в температурной кривой	6 хорошо выраженные флюктуации в температурной кривой
7 До 1 года	42	68,0	28,5	3,5
8 От 1 года до 2 лет	34	17,6	29,4	53,0
9 Свыше 2 лет	54	5,6	22,2	72,2

1 - Length of work in the Transpolar region
2 - Number of individuals investigated
3 - Percentage of individuals in whom were found manifestations of:
4 - absence of fluctuations in the temperature curve
5 - very slight fluctuations in the temperature curve
6 - well-pronounced fluctuations in the temperature curve
7 - up to one year
8 - from one year to two
9 - Over two years

Table 3

Changes in the skin temperature of the upper extremities following cessation of cooling (during the restoration period)

1 Стаж работы в Заполярье	2 Число обследованных лиц	3 Восстановление температуры кожи охлаждавшегося участка тела (кисти)	
		4 частичное	5 полное
6 До 1 года,	42	71,2	28,8
7 От 1 года до 2 лет	34	25,0	75,0
8 Свыше 2 лет	54	13,4	86,6

1 - Length of work in the Transpolar region
2 - Number of individuals investigated
3 - Restoration of the temperature of the skin of the cooled area of the body (hand)
4 - partial
5 - complete
6 - up to one year
7 - from one to two years
8 - over two years

cooling.

Following cooling we observed the rate and completeness of restoration of skin temperature.

The results of these observations are cited in Table 3.

By complete restoration we mean restoration of the initial temperature of the skin of fingers, wrist or foot within 10 to 15 minutes, and by partial restoration we mean that the skin temperature did not reach its initial level within 15 minutes.

It is seen in Table 3 that in the majority of individuals who had worked in the Transpolar region less than a year (71.2 percent), there was incomplete restoration of the temperature of the skin. Moreover, in some of this group the skin temperature of the fingers and hand rose only a few degrees during the first 20-30 minutes following cooling and remained at this level for an extended period of time. On the other hand, in the majority of individuals with a work record in the Transpolar region of one to two years, there occurred complete restoration of the skin temperature to its initial levels on the cooled areas of the body. In individuals with longer work records in the Transpolar region (over two years), the number with complete restoration of skin temperature to initial levels was even greater. In the absolute majority of individuals of this group (86.6 percent) the skin temperature not only reached but even exceeded the initial temperature by several degrees.

On the basis of the results obtained we can conclude that as the period of work in the Transpolar region increases, there is observed more rapid and more complete restoration of the width of the lumen of the peripheral vessels in the areas of the body which had been exposed to cold.

The higher skin temperature on cooled areas of the body in individuals with an extended work record in the Transpolar region undoubtedly results in greater heat losses from the organism.

Changes in heat emission during the adaptation of humans to cold may also be detected directly. We employed for this purpose the S. Ya. Zarzhevskiy (1949) calorimeter, which makes it possible to measure the volume of heat passing through the body surface.

Before carrying out the observations, the calorimeter was attached to the dorsal surface of the wrist or foot and covered with rubber glove or rubber stocking, and then the extremity was exposed to cold. The heat flow was

measured by means of the calorimeter in all 130 individuals.

Upon immersion of the upper or lower extremities in water at five degrees, there was observed in all cases a marked increase in the heat flow, reaching mcal/cm^2/min.

In those who had lived in the Transpolar region less than a year the decrease in the heat flow proceeded fairly rapidly along a precipitable curve. In individuals with a work record in the Transpolar region of over two years this decrease of the heat flow proceeded more slowly along an inclined curve. In some individuals there was noted a periodic, brief increase of the heat flow.

It was found that, on the average, toward the end of a 30-minute cooling of the upper extremities the volume of heat flow was 126 mcal/cm^2/min in individuals who had lived in the Transpolar region less than a year, 17[illegible] mcal/cm^2/min in those with a record of one to two years, and 190 mcal/cm^2/min, in those with a record of over two years.

Analogous results were obtained in the cooling of lower extremities. In individuals who had lived in the Far North up to one year, the heat flow from the lower extremities at the end of the cooling period did not exceed, on the average, 96 mcal/cm^2/min, and in those who had lived there two years and more, 140 mcal/cm^2/min.

The increased heat flow in the cooling of the aforementioned body areas in individuals who had lived for a long time in the Transpolar region is caused by a relative decrease in the constriction of the peripheral vessels under the effect of cold.

The question arises as to the purpose of this physiological reaction, which at first glance may seem to be inadequate because it leads to an increased loss of heat. I. P. Pavlov wrote in his course of lectures in physiology: "The organism possesses general functions and general requirements, and particular functions and requirements. The general requirement of the organism in frost is constriction of the vessels, and at the same time there originate also particular requirements -- the need to warm up the ear, cheeks, i.e., to dilate their cutaneous vessels. Here a struggle originates between the general and particular requirements; sometimes it is necessary to intervene consciously in this contest -- in a frost we rub our ears, thus accelerating the dilation of blood vessels, etc."

By employing the S. Ya. Zarzhevskiy calorimeter we were able to calculate the total volume of heat losses from the entire cooled surface. It was found that under

equal conditions of cooling, heat losses from the lower extremities in individuals who had served in the Transpolar region for extended periods of time exceeded the heat losses in individuals with a short period of service by only 0.06 to 0.07 kcal/min. The corresponding figure for the cooling of upper extremities was 0.05 kcal/min.

Thus the overall increase in the heat losses in local cooling, i.e., the "damage" to the general requirements of the organism, is negligible in individuals who had lived in the Transpolar region for an extended period of time. On the other hand, satisfaction of "particular requirements," i.e., protection of cooled areas of the skin from injury, is considerably improved.

Conclusions

1. The high level of heat flow as well as the slow decrease in the skin temperature on cooled areas of the body in individuals with a long work record in the Transpolar region indicates higher heat losses upon cooling in these individuals than in those whose work record under similar conditions was brief.

2. Restoration of skin temperature following cooling proceeds more rapidly in individuals with a long work record in the Transpolar region. In individuals with a brief work record under these conditions the heat restoration proceeds sluggishly and extends for a protracted period of time.

The data obtained may be utilized not only as objective indicators in evaluating the adaptation to cold by the population of the Transpolar region, but also in carrying out a number of hygienic measures in regard to clothing, nutrition ratio, development of parameters of the air medium in the industrial and residential quarters in the Transpolar region, etc.

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