The Circulation in Cold Acclimatization

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The hand and forearm blood flow of the Eskimo has been found to be greater than that of a control group of white persons in a temperate climate both at rest at an ambient temperature of 20°C and during acute cold exposure. Under cold stress, rectal temperature was better maintained in the Eskimos, though certain deep muscle temperatures fell more than they did in the white men because of the greater blood flow through exposed parts. The Eskimos showed an elevation of basal metabolic rate and of plasma and total red cell volume. There are similarities between the circulatory changes found in the Eskimo and those found in hyperthyroidism.

It is well known that the effects of acute cold exposure are peripheral vasoconstriction, diuresis and hemoconcentration. Two questions arise in connection with long-term cold exposure or cold acclimatization. Is the vascular response to acute cold exposure different in the acclimatized person? Does the acclimatized person, as compared with the unacclimatized, show changes in peripheral circulation when both are at a reasonably comfortable ambient temperature? Studies of the vascular dynamics of acclimatized persons have so far been few. The most important have been those of Balke, Cremer, Kramer and Reichel who studied skin temperature changes in men exposed to moderate cold for 28 days, and those of Carlson and his colleagues who studied skin, muscle and rectal temperatures in subjects who had been exposed for various times. In this report there are presented the results of studies of peripheral blood flow, skin, subcutaneous, muscle and rectal temperatures in acclimatized and non-acclimatized subjects, both during acute cold exposure and at a comfortable ambient temperature. Data have also been obtained on the basal metabolic rate and on the blood volume while at rest.

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Methods

The cold-acclimatized subjects for these experiments were chosen from Eskimos on Southampton Island, Northwest Territories. Here the Eskimo still live the traditional native life and gain their livelihood by hunting, fishing and trapping. They are thus frequently exposed to cold. The experiments on the Eskimos were performed during July and August 1949 and 1950, months during which they live in shacks or tents. The mean daily maximum temperature for July and August over a seven-year period (1943-1950) was 53.6°F, and the mean daily minimum temperature was 38.1°F. During January, when the Eskimos live in shacks or igloos, the mean daily maximum and minimum temperatures, over the same seven-year period, were −16.7°F and −32.5°F, respectively. Temperatures recorded at 6:30 a.m. in two representative shacks during the month of April ranged between 28°F and 52°F. In two igloos, at the same time of day and during the same month, temperatures between 17°F and 32°F were recorded.

Fifty-nine healthy male Eskimos between 18 and 50 years of age were used for the peripheral circulatory and tissue temperature studies. They were not all full-blooded Eskimos. Measurements of the blood flow in the hand and forearm were made with a Lewis-Grant type of venous occlusion plethysmograph. The temperatures of the skin, subcutaneous and muscle tissue of the forearm, skin of the hand, and rectal temperature were obtained with thermocouples. Skin temperature of the hand was recorded from the thenar eminence, the dorsum of the hand and the dorsal surface of the distal phalanx of the first, third and fifth fingers. The average value is reported. The blood pressure was recorded with a sphygmomanometer, and the heart rate was counted from the radial pulse. For all studies the subjects lay on a couch with trunk and head elevated to an angle of 30 degrees and arms at heart level. A 30-minute rest period was allowed before any measurements were made. Room temperature was kept at
20°C ± 0.5°C, and relative humidity at 50 to 60 percent.

Four groups of observations were made. (1) The temperatures of the forearm tissues were measured immediately after the forearm was bared, and these temperatures, recorded within one minute after baring, were considered the temperature of the clothed forearm. Rectal temperatures were recorded at the same time. (2) With the arms exposed to room air at 20°C, the temperature and blood flow in the artificially clothed forearm and the hand (cotton wool) were recorded over a two-hour period. The plethysmographs were not ventilated. (3) Hand blood flow, and temperature and blood flow in the forearm were measured during direct exposure of the hand and forearm to waterbaths at 5°C, to 45°C. Except for the experiments in the control group at 5°C, the observations were made over a two-hour period. (4) The hand blood flow and the forearm blood flow and temperature were measured over a two-hour period during which the feet and legs were cooled or heated by immersing both lower extremities in a water bath up to a point five inches below the upper end of the tibia. The cold bath was 10°C and the hot was 42.5°C. In these experiments the forearm blood flow was measured at a water-bath temperature of 34°C and the hand blood flow at 32°C, water-bath temperatures which had been found to maintain flows similar to those seen in the hand and clothed forearm at a room temperature of 20°C.

The control group used for the vascular experiments was composed of 85 male, healthy medical students, who were studied during September and October 1951, at which time the outdoor temperature in Kingston, Canada, corresponded to the outdoor temperature on Southampton Island during July and August. The clothing worn by the Eskimos and by the control group was the same (wool shirts, trousers, underwear, socks) except that the Eskimos wore sealskin mukluks and the medical students wore oxfords.

Basal metabolic rate was determined in four male and four female Eskimos between 18 and 48 years of age. Oxygen consumption was measured with a Benedict-Roth type of spirometer, DuBois' charts were used to determine surface area, and DuBois' standards as modified by Boothy and Sandford were taken as the normal. Only those subjects were used from whom two satisfactory tracings were obtained during preliminary tests. All subjects were studied in the fasting state between 4:30 and 9 a.m., while they were still in bed in their own tents or shacks. Blood volume was determined by a modification of the method of Gregerson in eight male Eskimos between 17 and 27 years of age.

**Results**

**Peripheral Circulation**

The Eskimos were found to be comfortable at a much lower ambient temperature than were the members of the control group, and it was after a survey of temperatures of their shacks and tents in July that 20°C was finally

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<th>Table 1.—Blood Flow and Tissue Temperatures at Room Temperature 20°C.</th>
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<td><strong>Group</strong></td>
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<td>Forearm baring temperatures (°C.)</td>
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<td>Skin</td>
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<td>Hand temp. (°C.)</td>
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<td>Rectal temp. (°C.)</td>
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<td>Forearm blood flow (cc./100 cc. tissue/min.)</td>
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<td>Hand blood flow (cc./100 cc. tissue/min.)</td>
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selected as the ambient temperature at which the experiments would be carried out. At this temperature the average skin temperature of the clothed forearm of the Eskimos was higher than that of the white men (p = 0.02), though there was no difference in subcutaneous, muscle or rectal temperature (table 1). When the observations were continued for two hours with the hand or the arm in the plethysmograph, which provided rather more insulation for the part to be studied than did the cotton wool, it was found that the blood flows in both the hand and forearm were greater in the Eskimos. The higher blood flow in the Eskimos was accompanied by higher skin temperatures of both hand and forearm, and gradually rising subcutaneous and muscle temperatures. The rectal temperature was essentially the same in the two groups and remained unchanged.

When the limb being studied was immersed in a water bath at a slightly lower temperature (30°C.), there was little change in the volume of the hand blood flow but, as at all water-bath temperatures between 5°C. and 33°C., the blood flow was greater in the Eskimos (7.1 ± 0.43 as compared with 3.8 ± 0.23 cc. per 100 cc. of tissue per minute). The blood flow in the forearm was also greater (3.2 ± 0.12 as compared with 2.8 ± 0.16 cc. per 100 cc. of tissue per minute), though there was a slow decrease in the volume of flow during the two-hour period (figs. 1 and 2). The subcutaneous temperature fell slightly and to the same degree in the two groups. Muscle temperature fell slightly more in the Eskimos than in the white men, and the rectal temperature remained unchanged.

When the limb was exposed for two hours to 10°C. and 20°C. water baths, there was a marked reduction in both hand and forearm blood flow and, in fact, it was at these temperatures that the lowest blood flows in hand and forearm were recorded (fig. 3). The rate of fall of the hand blood flow was always slower
in the Eskimos than in the controls, but the rate of fall of the muscle temperature was faster in the Eskimos, though the final temperatures arrived at in both groups were not greatly different. The average rectal temperature fell 0.3 C. in both groups during the 20 C. experiment and 0.5 C. in the 10 C. experiment. With exposure of the hand and forearm to water at 20 C., there was no significant difference between the blood pressure changes seen in the two groups, but at 10 C. the average blood pressure of the Eskimo during the two-hour observation period (114/80) was significantly higher than in the previous rest period (101/63). The members of the control group, on the other hand, showed no change in blood pressure.

Exposure of the upper limb to extreme cold (5 C. water bath) was tolerated by the Eskimos without difficulty whereas the white men could stand it only for one hour. As with exposure to moderate cold, there was a difference in the blood pressure reactions. The average blood pressure of the Eskimo during the two-hour period was 142/97 as compared with a resting level of 101/64. The white man showed a lesser elevation; 129/100 as compared with 123/91. On acute exposure of this type the hand blood flow was finally greater than at 10 C., and though the average flow was not as high in the white man as in the Eskimos, the increase in the blood flow over that seen at 10 C. was greater in the white man. In the forearm, the blood flow increased markedly in the Eskimo to approximate the levels recorded at water temperatures of 30 C. The control group showed very little increase in forearm blood flow. Though the forearm blood flow was more than twice as great in the Eskimo (3.8 ± 0.12 as compared with 1.5 ± 0.6 cc. per 100 cc. of tissue per minute), the muscle temperature at the end of an hour was 18 C. in the control group as compared with 12.5 C. in the Eskimo. Also, the rate of fall of muscle temperature was less in the control group. The behavior of the subcutaneous temperatures paralleled that of the muscle temperatures. In the Eskimos, the rectal temperature after two hours was 0.5 C. below the preimmersion level; in the white men it was 0.7 C. lower after 50 minutes.

When the hand and forearm were exposed to heat as in a water bath at 42.5 C., subcutaneous and muscle temperature showed a marked increase and the final levels achieved were the same in the Eskimos as in the white men. The speed with which the high level was achieved was the same in the two groups. Both hand and forearm blood flows, however, were greater in the Eskimos, and in the case of the forearm, the rate at which blood flow increased was also greater in the Eskimos. Though the average final blood flow in forearm was less in the white man, the augmentation of blood flow which occurred on immersion in a warm bath was greater than that seen in the Eskimo, due to the fact that the initial levels were lower in the white man.

When heat was applied to the body by immersing the legs in water bath at 42.5 C.,

![Graph](http://circ.ahajournals.org/)  
**FIG. 4.** Effect on hand and forearm blood flow and tissue temperatures of immersion of feet and legs in water bath at 42.5 C.
the blood flow of hand and forearm naturally increased (fig. 4). In the case of the hand, the final level of blood flow became the same in the two groups, which meant that the percentage increase was greater in the control group. In the forearm, the blood flow increased more rapidly in the control group and the final levels reached were higher. Forearm muscle temperature increased 1.5°C in the white men as compared with 0.5°C in the Eskimos. Subcutaneous tissue temperatures in both groups increased by 0.5°C throughout the first hour, and the rectal temperature increased by 0.6°C during the same period.

When heat was removed from the body by immersing the legs in a water bath at 10°C, the hand blood flow in the Eskimos fell slightly below the preimmersion level in 10 minutes and remained at approximately this level throughout the 2-hour period of the experiment (fig. 5). By contrast, the hand blood flow of the control group, after some variation for 15 minutes, fell to a much lower level, which was maintained throughout the two-hour period. The final result under these conditions was that the hand blood flow of the Eskimo was about twice that of the white man. In the same circumstances, there was no significant change in the forearm blood flow of the Eskimo, whereas after 30 minutes there was a fall in that of the white man. The alterations in blood flow were not accompanied by changes of any size in subcutaneous, muscle or rectal temperatures. In these experiments, as in all the others, the fluctuations from time to time in individual blood flows, in both the hand and the forewarm, were greater in the Eskimos than in the white men.

Subjective Response to Cold

The ability of the Eskimo to withstand the cold was evident on casual observation. Swimming in the sea on the occasional fine day, pouring over themselves sea water at 2.0°C on a cool September evening, and their ability to work with bare hands and to continue to perform fine movements in the winter cold are examples of this. At the same time, their heat tolerance is diminished, and they were often uncomfortable and perspiring while in our laboratory huts.

Differences from the white man were also noted in the sensations the Eskimo experienced after the application of local cold. When the arm was immersed in a water bath at 20°C, a transient sensation of coldness occurred in both groups. With the arm in the 10°C water bath, the Eskimo experienced a sensation of coldness upon immersion but there was no pain, and the three subjects studied were asleep within 20 minutes. The four subjects in the control group experienced first a sensation of severe coldness in the immersed arm, and a deep, aching pain developed which reached maximum intensity in about three minutes and then decreased to disappear after about 10 minutes. The sensation of coldness persisted but diminished somewhat in intensity. None of the control group was able to sleep. When the arm was immersed in the 5°C water bath, the Eskimo complained of severe coldness and also of a deep aching sensation during the first five minutes. Two of the three subjects were able to sleep within 20 to 30 minutes. The three men in the control group complained of severe local coldness upon immersion of the arm with the rapid development of a deep,
aching pain which reached its peak intensity within 1 or 2 minutes. In all the control subjects the sensation of coldness diminished but did not disappear, and throughout the entire period of immersion of the arm, transient burning sensations occurred in all three subjects. This sensation was restricted to the skin and was frequently precipitated or made worse by local pressure. None of these men was able to sleep.

**Basal Metabolic Rate**

Four series of determinations of the basal metabolic rate were made at approximately fortnightly intervals between July 11 and Aug. 29, 1949. The results as shown in table 2 indicate a significant elevation, which becomes less marked as the summer progresses.

**Blood Volume**

The average blood volume of the Eskimos was found to be markedly elevated throughout the period of observation from July 12 to Aug. 20, 1950 (table 3). As with the basal metabolic rate, the elevation was greater in the earlier observations. An increase of both plasma and total red cell volume contributed to the increase in total blood volume, and the fall in plasma volume which occurred during the summer was greater than the fall in total red cell volume.

**Discussion**

Consideration of these results and of reports of other experiments in the literature leads to the conclusion that the circulatory changes which follow exposure to the cold pursue a phasic pattern. On acute cold exposure it is well known that there is vasoconstriction, and accompanying this there is reduction of circulating blood volume.\(^5\), \(^6\), \(^7\) If cold exposure is continued, there is some lessening of the vasoconstriction as shown by skin temperature changes.\(^8\), \(^9\) There is also a return of the circulating blood volume towards normal. This is hinted at by Bazett, Sunderman, Doupe and Scott,\(^5\) and documented with experimental data by Spealman, Newton and Post.\(^3\) Further continuation of cold exposure, or what can be termed long-term exposure, leads to complex changes. There is then subjective comfort at a lower ambient temperature\(^10\) and, as reported now, a change in the pattern of the different types of discomfort which occur on severe local cold exposure. These subjective phenomena are accompanied by evidence of an enhanced peripheral circulation which persists between cold exposures. At a comfortable ambient temperature there is an increased blood flow through hand and forearm as compared with controls, and an increased skin temperature over hand and forearm,\(^10\), \(^11\), \(^12\), \(^13\) though only the difference in forearm skin temperature has been found to be statistically significant. This increase in peripheral blood flow at rest is accompanied by an increase in both plasma volume and total red cell volume which indicates that enhancement of the peripheral circulation is not necessarily accomplished at the expense of the visceral blood supply. It is the fact that the peripheral circulation and the blood volume behave in this phasic fashion in response to cold which has led to so much confusion in the literature concerning the effect of cold and the existence of acclimatization to cold in man. Actually, the findings in any particular experiment will depend on the previous cold experience of the subjects, the clothing, and the duration and severity of the cold
exposure, all of which should be defined in acute or short-term experiments.

In those who have been subjected to long-term cold exposure, that is, in those who may be said to be acclimatized, there are alterations in the response to acute cold which are rather complex. As in the unacclimatized, there is peripheral vasoconstriction. Comparative studies of cold diuresis and reduction in blood volume have not yet been made. In our experiments the reduction which was seen in the hand blood flow of the acclimatized Eskimo when the hand and forearm were placed in the 5 C. water bath, was actually greater than that recorded in the controls, but the final level at which blood flow stabilized at this temperature was higher than in the controls. In all water bath temperatures from 5 C. to 33 C. this enhanced blood flow has been seen in both hand and forearm in the Eskimos. The greater circulation of blood through the hand and forearm exposed to the cold means a greater cooling of the deep tissues of the forearm. A comparison of the tissue temperatures and the blood flows in these experiments with the tissue temperatures in our experiments in which the legs and feet were cooled, indicates that the lower muscle temperature in the Eskimo on severe cold exposure is due to cooling by the mechanism described by Pennes\textsuperscript{14} and by Bazett, Love, Newton, Eisenberg, Day and Forster\textsuperscript{15} and by Bazett, Mendelson, Love and Libet.\textsuperscript{16} Carlson and his colleagues\textsuperscript{2, 3} have also recorded muscle temperatures in the arm and leg which are consistent with this view.

The improved maintenance of rectal temperature in the acclimatized despite greater heat loss from the extremities, which has now been reported, could be the result of (1) greater cooling of other tissues than those in the body core and in the extremities, (2) more efficient control of heat loss from sites other than the extremities, or (3) greater heat production during the period of exposure. Attention has been drawn by Carlson and his colleagues\textsuperscript{2, 3, 12} to the contribution made by the tissues of the acclimatized which are cooled to a greater degree. Carlson, Young, Burns and Quinton,\textsuperscript{12} after finding in their short experiments that the oxygen consumption was greater in the unacclimatized and the total heat loss and the rectal temperatures were the same as in the acclimatized, concluded that the size of the contribution of heat made in this way was what distinguished the acclimatized subjects. It would appear that this contribution may be comparatively small. Horvath and Golden\textsuperscript{17} found in experiments which covered a wide range of exposure that the heat debt was incurred during the first 10 minutes. In our own experiments the tissue temperature changes in the forearm also indicate that the adjustment is made fairly rapidly, and the contribution which was made by tissue subjected to greater cooling by the increased venous drainage from the exposed parts must have been relatively small. The continued maintenance of an enhanced peripheral circulation in the acclimatized must, of course, be dependent on other mechanisms.

There is no evidence available to support the suggestion that, under conditions where the cold exposure is great enough to cause a fall in rectal temperature, the acclimatized have more efficient control of heat loss from sites other than the extremities. There is, however, evidence which indicates that there is greater heat production by the acclimatized. Our own results show an elevation of the basal metabolic rate in the Eskimos studied and Gottschalk and Riggs\textsuperscript{18} found an increase in the serum protein-bound iodine in the same group. Newburgh and Spealman\textsuperscript{19} reported a slow increase in basal metabolic rate in white men living in light clothing at a temperature of 15 C., and Horvath, Freedman and Golden\textsuperscript{20} found an increase in sitting oxygen consumption in their white subjects who spent eight days in a room at −29 C. dressed in suits which had an insulative value of 3 to 4 clo. The animal experiments of Ring\textsuperscript{21} and of Sellers and You\textsuperscript{22} have also yielded evidence of increased oxygen consumption under basal conditions following long-term exposure to cold. The evidence concerning oxygen consumption during acute exposure is conflicting. Carlson, Young, Burns and Quinton\textsuperscript{12} found a greater oxygen consumption in the unacclimatized during a short exposure to temperatures
Fortunately, Reichel1 found no difference in oxygen consumption in their subjects during 20 minutes in a 20°C bath after a four-week exposure which was very moderate in degree. Unfortunately we have no data in our own experiments on the oxygen consumption of our two groups of subjects during acute exposure. The animal work, however, is clear cut. Sellers, Reichman, Thomas and You23 found that exposure to cold for four to six weeks led to an increased ability to maintain a high level of heat production during acute severe cold exposure, and this has been confirmed by Blair.24

The results now reported are consistent with the hypothesis that heightened thyroid activity plays a role in the increased heat production which we consider to be a feature of acclimatization to cold. For one thing, the pattern of the changes in the peripheral circulation which we have noted in the Eskimo is similar to that seen in hyperthyroidism. In the Eskimo, who has been exposed repeatedly to the cold, there is an increased skin temperature over hand and forearm with an increased blood flow to these same parts, and the spontaneous fluctuations which are seen in hand and forearm blood flow are greater. In cases of hyperthyroidism there have been demonstrated increased blood flow in the hand, forearm blood flow, increased blood flow through the skin27 and increase in the spontaneous fluctuations seen in peripheral blood flow.28 The increase in blood volume which is now reported is another suggestive point. In hyperthyroidism it is known that there is an increase in blood volume, and for corresponding basal metabolic rate values the increase in blood volume observed in hyperthyroidism has been reported to be approximately the same as that observed in the Eskimo.31 Finally, the increased basal metabolic rate which we have found in our group of Eskimos points to increased thyroid activity, and the supporting work of Gottschalk and Riggs37 on the same group of Eskimos has been noted.

There is also support for this hypothesis in animal work. Thyroid hyperplasia has been seen in the rat after prolonged cold exposure, and Sellers and You22 have found evidence of increase in thyrotrophic activity of the pituitaries of rats exposed more than two weeks to 1.5°C. Sellers and You22 also found that survival of rats in the cold was prejudiced by thyroideotomy or the administration of propylthiouracil, and that anesthesia, calculated to abolish the heat contribution made by increased muscle tone, did not abolish the increased oxygen consumption at 30°C, which is one of the characteristics of rats exposed for two or more weeks to the cold. The same workers have gone on to demonstrate increased oxygen consumption and succinoxidase activity of liver tissue in rats after exposure of rats to cold for more than 16 days. Scott, Thomas and Sellers24 have further emphasized the importance of the increased rate of metabolism of visceral tissues by demonstrating that the electrical activity of the thigh muscles of acclimatized rats was lower both at 2°C and 30°C than was that of normal nonacclimatized animals. It is interesting in this connection that a surprising incidence of hepatomegaly has been noted in the Eskimo and that in rats exposed to the cold there is also enlargement of the liver.35 You and Sellers25 have also reported enlargement of the liver after exposure of rats to the cold. Baker and Sellers, continuing their work on the metabolism of cold acclimatization, have found that the glycogen content of the heart, liver, diaphragm and of fat from perirenal and interscapular regions of the rat acclimatized to cold is reduced as compared with the unacclimatized animal. The blood sugar levels and the glycogen content of the skeletal muscles were unchanged. Cold acclimatized rats also show increased insulin sensitivity.

Though it is our conclusion that heightened thyroid activity has a role in the increased metabolic heat production which is a feature of cold acclimatization, it is not our belief that an increase in the secretion of the thyroid hormone is necessarily the sole agent responsible. The work of King30 showed that the effect of thyroxin consisted of more than its direct
effect on basal metabolism. He found that the calorigenic response to epinephrine was poten-
tiated by thyroxin, as was the maximum calorigenic response to cold. After prolonged
cold exposure of rats he found the calorigenic
effect of epinephrine to be about what would
be expected from an equivalent increase in
basal metabolism caused by thyroxin admin-
istration. It was his conclusion that epinephrine
may account for 10 per cent of the increased
metabolism produced by cold. There is also
to be considered the suggestive work of Sellers
and his group. They found that adrenalectomy
reduced the survival time in the cold of both
acclimatized and nonacclimatized rats, and
that nonacclimatized animals survived longer
in the cold when they were pretreated with a
combination of thyroxin and cortisone than
they did when pretreated with either of these
alone. At the present time, it can only be said
that increased thyroid activity plays a part in
the complex metabolic adjustments which take
place during prolonged exposure to cold.

Summary

In a group of Eskimos in the Canadian
Eastern Arctic who still live in a fashion which
exposes them to severe cold, it was found that
the forearm skin temperature and the forearm
and hand blood flow were greater at rest in a
room at 20° C. than they were in a control
group of medical students. During immersion
of the hand and forearm in water baths at
temperatures of 5 to 42.5° C., the Eskimos al-
ways maintained higher blood flows in hand
and forearm than did the control group. In
the colder baths the forearm muscle tempera-
ture of the Eskimos fell more than it did in
the controls, but this is believed to be due to
greater blood flow through the exposed hand
and the resulting increased cooling of deep
tissues by the venous return. The evidence
is that the contribution made to the total
thermal requirements of the body by the
cooling of deep tissues was small.

Exposure of the hand and forearm to cold
caus ed a greater elevation of blood pressure
in the Eskimos than in the white men. There
was also a difference in the pain perceived by
the two groups. The Eskimos reported less
severe pain, and pain for a shorter period,
th an d did the controls.

The experiments on peripheral blood flow
suggested an increased heat production in the
Eskimos, and an average elevation of basal
metabolic rate of approximately 30 per cent
was found. There was also an elevation of
both plasma volume and total red cell volume.
Review of our own data and of other reports
in the literature provides support for the view
that increased thyroid activity is a feature of
the response to long term exposure to cold and
that the increased thyroid activity determines
the pattern of the vascular adjustments which
are made.

Se ha encontrado que la circulación de la
mano y el antebrazo del esquimal es mayor
que la de un grupo control de personas blancas
en un clima templado tanto durante el descanso como a una temperatura ambiente de
20° C. y durante la exposición aguda al frío.
Durante el esfuerzo al frío, la temperatura
rectal fue mejor mantenida en el esquimal,
aunque algunas temperaturas de músculo
profundo bajaron más que en las personas
blancas debido a la mayor circulación de las
partes expuestas. Los esquimales mostraron
una elevación del metabolismo basal y del
volumen total del plasma y eritrocitos. Hay
similaridades entre los cambios circulatorios
encontrados en el esquimal y aquellos en-
contrados en hipertrioidismo.

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