

Response of Negro and white males to cold

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IAMPIETRO, P. F., R. F. GOLDMAN, E. R. BUSKIRK AND DAVID E. BASS. *Response of Negro and white males to cold*. *J. Appl. Physiol.* 14(5): 798-800. 1959.—Heat production and body temperatures were measured in matched groups of U.S. Negro and white soldiers during whole body cooling and finger temperatures were measured when only the digits were cooled. Whole body cooling was accomplished by having the subjects, clad only in shorts, sit for 2 hours in a chamber at 50°F with a 5-mph wind. Digital cooling was accomplished by having the subjects immerse the fingers in a water bath at 32°F for 45 minutes. During whole body cooling there were no group differences with respect to the following: heat production, skin and rectal temperatures. During digital cooling white subjects had higher finger temperatures and the 'hunting' reaction was more pronounced than for Negroes. In addition, the white subjects required a shorter period for the onset of the first 'rewarming' of the fingers. The implications of these findings with reference to the reported higher incidence of cold injury among Negro soldiers are discussed.

SOME WORKERS HAVE REPORTED differences in the responses to cold and in the incidence of cold injury among various racial and ethnic groups, i.e. Eskimo, Negro and Caucasian. Thus, various authors have observed that Negro subjects had a smaller and more delayed increase in heat production during cold exposure than either Eskimo or Caucasian subjects (1, 2), and that rewarming of the fingers was not as pronounced for Negro subjects as for Caucasians (2, 3). Orr and Fainer (4) reported a higher incidence of cold injury in Negroes than in Caucasian soldiers stationed in northern areas. Meehan (3) has suggested that individuals with a history of frostbite do not maintain digital blood flow during local cooling as well as individuals who have never had frostbite. However, there has been no clear demonstration that the responses of white or Negro subjects during immersion of the fingers in cold water have any relationship to the responses during whole body cooling.

The purpose of this study was to compare U.S. Negro and white soldiers with respect to: a) body heat exchanges during acute cold exposure and b) finger cooling and rewarming, i.e., 'hunting' reaction, during immersion of the digits in cold water.

METHODS

Seventeen white and 16 Negro volunteer subjects were exposed nude (except for cotton shorts) to cold (D.B. 50°F, R.H. 50%, wind 5 mph) for 2 hours on two separate occasions, 8 days apart. Cold exposure was preceded by a 1-hour 'equilibration' period at 80°F, R.H. 50%. The first exposure served to familiarize the subjects with the various measurements and instruments and to alleviate any fears of possible untoward effects of the cold exposure. All subjects were healthy, young soldiers and were matched as closely as possible for physical characteristics (table 1). Originally 17 white soldiers were matched with an equal number of Negro soldiers. Subsequently, one Negro was dropped for reasons beyond our control.

The subjects were exposed to cold in groups of six (3 white and 3 Negro subjects), except for the last day on which only three subjects were exposed, and only one group was studied on a given day. All subjects were in a fasting state. The following measurements were made during both control and cold periods: skin temperature (T_{sk}), rectal temperature, and oxygen consumption ($\dot{V}O_2$). Skin temperatures were measured with copper-constantan thermocouples placed at 11 points on the

TABLE 1. *Some Characteristics of Test Subjects*

	Age, yr.	Weight, kg	Height, cm	Surface Area, M ²	% Fat ^a
<i>Negro, 16 Subjects</i>					
Mean	22.3	68.55	171	1.79	9.3
Range	18-33	61.6-79.5	165-178	1.67-1.89	7.1-12.8
<i>White, 17 Subjects</i>					
Mean	21.1	69.61	172	1.80	9.7
Range	19-25	61.1-78.9	164-182	1.69-1.97	7.1-13.3

^a Estimated from skinfold measurement.

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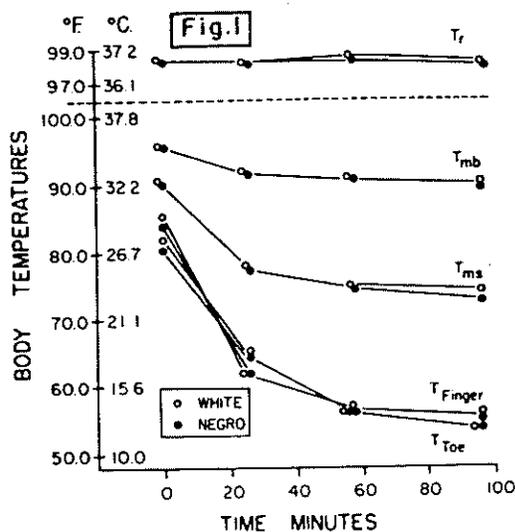
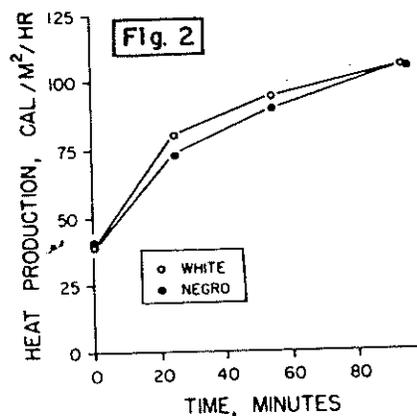


FIG. 1. Body temperatures of Negro and white subjects during exposure to cold.

FIG. 2. Heat production of Negro and white subjects during exposure to cold.



skin (great toe, instep, calf, medial and lateral thigh, chest, back, upper and lower arm, little finger and forehead). Rectal temperatures were measured with similar thermocouples. $\dot{V}O_2$ was determined by collecting expired air in a Tissot spirometer and analyzing the expired gas for oxygen with a Beckman O_2 analyzer. Heat production was calculated according to the method of Weir (5). Calculations of mean weighted skin temperature and mean body temperature were made (6). The test subjects were in a semireclining position during both equilibration and cold periods. They were wheeled, in their chairs, from one chamber to the other to avoid activity.

A *t* test was used for statistical comparison of the data (7). Differences were considered significant when the probability of identity equaled .05.

A schedule similar to the foregoing was used for measurement of digital cooling with regard to orientation, fasting and time of day. Subjects reported to the test room (80°F, 40% R.H.) and rested quietly for 30 minutes before measurements were made. The army fatigue uniform was worn throughout the experiment. The fingers of the right hand were immersed to the metacarpal-phalangeal joints for 45 minutes in a stirred, constant temperature water bath maintained at 0°C. A copper-constantan butt-soldered thermocouple (#38 SWG) was taped to the tip of the middle digit and a loosely fitting rubber surgical glove was worn during the immersion. Thermocouple output was recorded continuously on a Bristol millivolt recorder having a full scale excursion of 1.1 mv. With this instrument the temperature of the finger could be determined within 0.1°C.

The results were obtained in the form of a curve representing the temperature of the surface of the finger tip during the 45-minute immersion. This curve was analyzed, using the technique suggested by Yoshimura and Iida (8), as follows: 1) mean temperature from the

TABLE 2. Comparison of Responses of Negro and White Subjects to Finger Cooling

Parameter of Finger Cooling	White, Mean of 17 Subj.	Negro, Mean of 16 Subj.	P
Mean surface temperature (5th-30th minute)	7.2°C	2.7°C	<.01
Time to first rewarming	9.2 min.	15.9 min.	<.05
Surface temperature at which 1st rewarming began	2.9°C	1°C	<.05
Surface temperature at crest of 1st rewarming cycle	11.4°C	5.7°C	<.01
Minimum surface temperature during 45-minute immersion	1.8°C	0.3°C	<.05

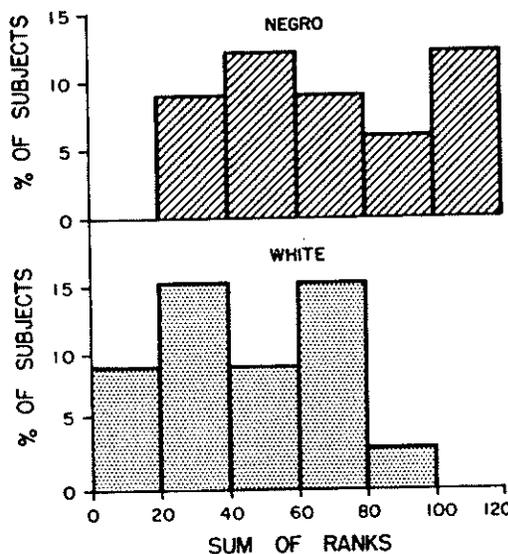


FIG. 3. Distribution of Negro and white subjects with respect to the sum of ranks of four criteria of digital cooling.

5th to 30th minute of immersion, 2) time elapsed between immersion of finger and first rewarming, and 3) finger temperature at which first rewarming started. In addition, the lowest temperature during the entire period of immersion was recorded. The data were analyzed by means of *t* tests on the four variables (7).

RESULTS

Skin, rectal and mean body temperatures. Body temperatures are shown in figure 1. There were no significant differences between groups with regard to rectal temperature (T_r), mean body temperature (T_{mb}), finger temperature (T_{finger}) and toe temperature (T_{toe}) during both control and cold periods. The foregoing applies to mean weighted skin temperature (T_{ms}), with the exception that T_{ms} after 100 minutes in the cold was 1.6°F lower in the Negroes than in the white subjects; this difference, though small, approximated statistical significance ($P = .05$). Fingers and toes cooled at the same rate and to the same extent in both groups. The extremities cooled to within 5–6°F of the ambient temperature.

Heat production. Heat production (fig. 2) increased rapidly for the first 30 minutes of cold exposure and increased more slowly during the next 70 minutes. Both Negro and white subjects had the same control heat production and both groups increased heat production at the same time and to the same degree. Heat production after 100 minutes of exposure (105 Cal/m²/hr.) was 2½ times the control values.

Digital cooling. These results are shown in table 2. The following temperatures were significantly lower for the Negro group during finger cooling than for the white group: a) mean surface temperature 5th to 30th minute, b) surface temperature at which first rewarming began, c) surface temperature at crest of first rewarming cycle, d) lowest surface temperature during entire immersion period. In addition, the time to first rewarming was longer in the Negro. A noticeable feature was the markedly greater rewarming shown by the white subjects, i.e. their surface temperature at the crest of the first rewarming cycle was 11.4°C as compared to 5.7°C for the Negroes (table 2). Several of the Negro subjects showed no rewarming whatever during the entire 45-minute immersion, and the majority of the Negro subjects had temperature increases of relatively low amplitude. When all individuals were ranked with respect to these four criteria, there was a predominance of white subjects in the highest ranking and of Negroes at the lowest. This is shown in figure 3, in which frequency is plotted against the sum of the four ranks for each subject.

REFERENCES

- ADAMS, T. AND B. COVINO. *J. Appl. Physiol.* 12: 9, 1958.
- RENNIE, D. W. AND T. ADAMS. *J. Appl. Physiol.* 11: 201, 1957.
- MEEHAN, J. P. Arctic Aeromedical Laboratory, Proj. No. 7-7953, Rep. No. 1, Ladd Air Force Base, Alaska, 1955.
- ORR, K. D. AND D. C. FAINER. *Medicine* 31: 177, 1952.
- WEIR, J. B. DEV. *J. Physiol.* 109: 1, 1949.
- IAMPIETRO, P. F., E. R. BUSKIRK AND D. E. BASS. *J. Appl. Physiol.* 12: 351, 1958.
- FISHER, R. A. *Statistical Methods for Research Workers* (8th ed.) London: Oliver, 1941.
- YOSHIMURA, H. AND T. IIDA. *Japan. J. Physiol.* 2: 177, 1952.
- BLAISDELL, R. K. Quartermaster Climatic Research Laboratory, Rep. No. 177, Lawrence, Mass., 1951.

Thus, 9% of the subjects fell within the first class interval (0–20); all these subjects were white. Twelve percent of the subjects fell within the last class interval (100–120), and all were from the Negro group.

DISCUSSION

The results of this study indicate that Negroes and white subjects respond to a whole body cold stimulus in a similar fashion. This is not in agreement with the findings of others (1). Under our conditions there were no important differences in the responses of Negro and white subjects with regard to the following: heat production, finger, toe, and mean weighted skin temperatures and rectal temperature. However, we found, in agreement with others (2, 3), that the fingers of the Negro subjects during local cooling had fewer rewarming cycles and also tended to cool more than did those of white subjects. In addition, the time for rewarming, when rewarming occurred, was prolonged for the Negro group.

It is noteworthy that the Negro and white subjects had similar finger temperatures during total body cooling, whereas the white groups had higher finger temperatures when the fingers alone were cooled. This finding is difficult to interpret. In this connection, Blaisdell (9) has demonstrated that the hunting reaction is depressed by total body cooling, i.e. the more chilled the individual the lower the finger temperature at which the hunting reaction occurs. It is therefore possible that any lability of finger temperature displayed by the two groups during immersion of the fingers in cold water was depressed during whole body cooling, the white subjects being relatively more affected than the Negroes. As a result, the finger temperatures during total body cooling were essentially the same for both groups.

Others (1) have stated that Negroes may be more susceptible to cold injury than white persons, because they do not increase heat production as rapidly or to as great an extent. As mentioned above, the data on $\dot{V}O_2$ do not support this concept.

The differences in spontaneous rewarming of the fingers in Negro and white subjects, found in this and other studies, may provide a basis for the higher incidence of cold injury among Negroes. This assumes that there exists a relationship between spontaneous rewarming and susceptibility to frostbite. Further work is necessary to determine whether this is a valid assumption.

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