Studies on Clothing and Thermal Comfort in Antarctica

J. M. Loots
National Institute for Nutritional Diseases
S.A. Medical Research Council
Pretoria
and
M. Krüger
Medical Officer
South African National Antarctic Expedition 1967–68

Abstract

The general attitude of all members of the 8th South African National Antarctic Expedition to Antarctica both to environment and the clothing worn, was studied by means of a questionnaire on clothing and comfort. Although indoors the men felt comfortable at temperatures ranging from 3–16°C, they could detect changes in temperature of 2°C. At higher temperatures some of the men felt too hot. The preferred indoor temperature was 13,4°C. The overall picture gained from the outdoor studies was that as time passed and the men became more experienced they learnt how to be as comfortable as possible; for instance, they dressed more suitably for the conditions to which they were exposed in the second half of the year than during the first few months at the base. Comparisons were made between the amount of clothing worn and thermal comfort, both indoors and outdoors, and in the periods before and after midwinter. The results indicate that there was a certain measure of acclimatization to cold.

Introduction

The use of relatively sophisticated and often complicated methods (*Wyndham et al*, 1964; *Wyndham & Loots*, 1969), to establish whether any degree of acclimatization to cold occurs in people residing in polar regions for lengthy periods is not always practicable. A simple method is the use of clothing records, where the change with time in the amount of clothing worn by men exposed to cold-stress is studied (*Butson*, 1949; *Frazier*, 1945; *Goldsmith*, 1960; *Lugg*, 1965, and *Palmai*, 1962).

Frazier (1945) in Little America V, and *Butson* (1949) at Marguerite Bay, noted that as the weather grew progressively colder, little, if any, additional clothing was worn. *Goldsmith* (1960) at Shackleton Base, *Palmai* (1962) at Maquarie Island and *Lugg* (1965) at the Australian station Davis, kept accurate records of the amount of clothing worn and the degree of thermal comfort attained throughout the year. Contrary to the observations of Frazier and Butson, Goldsmith and Palmai found that men wore more clothing as the weather grew colder, although Palmai noted that there was no increase in the number of garments worn on the hands and feet. The observations of Lugg were similar to those of Frazier and Butson.

When days of equal wind-chill were compared, less clothing was worn in the second than in the first half of the year (*Goldsmith*, 1960; *Lugg*, 1965; *Palmai*, 1962). From these observations the authors concluded that acclimatization to cold did develop.

Indoor studies showed that, when social convention did not play a role in respect of dress, the men were able to achieve thermal comfort at all times by suitably varying or adjusting their clothing (*Lugg*, 1965; *Palmai*, 1962).

The general behaviour of all the members of this team in regard to the environment and the clothing worn was studied by the clothing-and-comfort technique employed by some of the workers mentioned above (*Goldsmith*, 1960; *Lugg*, 1965; *Palmai*, 1962).

Subjects and Methods

The 8th South African National Antarctic Expedition (SANAE) (1967) consisted of sixteen men who arrived at their base in January, 1967, and stayed in Antarctica until mid-February, 1968. The mean age, body-weight and height of these men on arrival are given in Table I. Sanae base (70°18′S, 2°21′W) is situated in Queen Maud Land on an ice-shelf. The main part of the base consists of eight buildings in a row, joined by a snow passage. At the beginning of 1967 the base was five

Table 1

The mean ages, body-weights and heights of the men on arrival in Antarctica, 1967

	Age (years)	Body-weight (Kg)	Height (cms)
Range	22–40	57,6–90,5	169,6–185,4
Mean	27,5	75,3	176,7

years old and was situated well below the snow surface, the floor-to-surface distance being approximately 25 feet.

The mean indoor temperature during the period studied was 16,9°C and the extremes of temperature recorded were 3°C and 24°C. These wide variations were due to occasional defects in the heating and ventilating systems.

The mean outdoor temperature for the period during which the study was undertaken was −17,4°C, the extreme temperatures recorded being −42°C and +4°C. The average monthly wind velocities varied from 12,5 to 22,5 knots (Fig. 2). The average wind velocity during the total period of the studies was 17,9 knots.

During the period February to December, 1967, precipitation of snow occurred on 105 days and snowdrift on 180 days.

The *comfort vote* technique of *Bedford* (1936) was used as the basis of the investigation. The subject recorded on a card his assessment of his thermal sensations, the amount of clothing worn and the type of activity in which he was engaged. Other details relevant to the investigation, such as the ambient temperature, wind velocity, etc. were entered subsequently.

The same type of card was used for both indoor and outdoor activities. These cards had provision on one side for entering details such as the subject's activity, thermal sensations of the trunk, the head, the hands and the feet, and the ambient temperature.

The thermal sensations were classified into seven categories: much too hot (+3), slightly too hot (+2), warm (+1), neutral (0), cool (−1), slightly too cool (−2) and much too cool (−3). The range comprising cool, neutral and warm sensations (−1, 0 +1) was accepted as being the comfortable range.

On the reverse side of the card the air movement, locality (in or outdoors) and the amount of clothing worn on the head, the trunk, the hands and the feet, were recorded.

Each garment was recorded as a layer of clothing, paired items such as socks and gloves being regarded as one garment.

The evaluation was effected at weekly intervals at 1500 hours. Evaluations which referred to disqualifying conditions such as working in front of a source of radiant heat, lying under blankets, or working in the snow passage, were not included in the analysis.

Ambient temperatures were not determined until evaluations had been completed.

Results and Discussion

Indoors.—The mean temperature to which the men were exposed at the time of recording, the mean comfort vote, and the mean number of garments worn on the trunk were determined for each month and are shown in Figure 1.

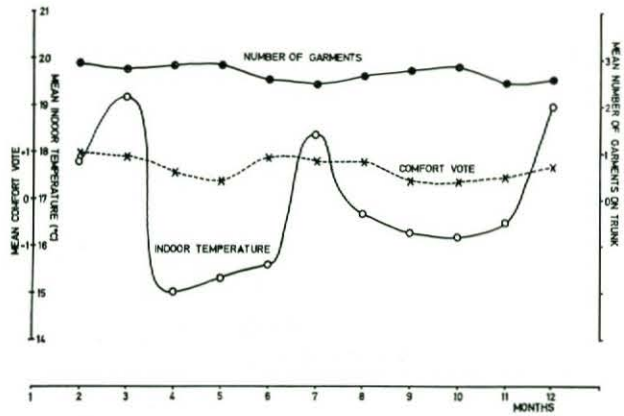

Fig. 1. Mean monthly values for: indoor temperature (dry bulb); indoor comfort vote and number of garments worn on the trunk indoors.

Because Sanae base was covered with a thick layer of snow, problems were encountered with the ventilation and heating systems. The heating system in the sleeping quarters was not reliable and temperatures as low as +3°C were occasionally recorded. Although two big extractor fans were used the generator room was usually very hot (21–24°C). The majority of the men, however, remained comfortable by making suitable adjustments to the type and quantity of clothing worn.

The records show that all the men felt comfortable at temperatures ranging from 3–16°C. At temperatures of 16–18°C and 18–21°C, on 6,7 and 19,1 per cent of the occasions, respectively, the men felt slightly too hot, and on 2 per cent of the occasions they felt uncomfortably hot at temperatures higher than 18°C (Table 2).

The men were comfortable in a wide range of temperatures, which is in keeping with the observation of *Lugg* (1965) that narrow comfort-zones are not discernible in polar regions.

Table 2

The relation between the percentage incidence of each thermal sensation and the amount of clothing worn to dry-bulb temperature indoors

Temp. °C	Percentage incidence of each thermal sensation					Mean number of garments on trunk
	+3	+2	+1	0	−1	
10–12	0	0	38,5	53,8	7,7	3,31
12–14	0	0	38,9	61,1	0	3,08
14–16	0	0	76,9	23,1	0	2,77
16–18	0	6,7	40,5	44,9	7,9	2,75
18–21	2,0	19,1	43,4	33,6	1,9	2,71

Table 3

A comparison between the mean thermal sensations and the amount of clothing worn on the trunk at an indoor temperature of 17°C before and after midwinter

Before midwinter		After midwinter	
Mean comfort vote	Mean no. of garments	Mean comfort vote	Mean no. of garments
+0,8	2,9	+0,7	2,4

Table 2 shows that the men could still detect changes in temperature of 2°C, in spite of the fact that conditions remained within this comfort zone. As the temperatures rose the men achieved thermal comfort by reducing their clothing. It appeared, however, that they preferred to be rather too warm than to remove a layer of clothing at the higher temperatures (16–21°C).

Scrutiny of the temperatures at the times of recording the comfort data indicated that the specific room temperature at which the highest percentage of subjects experienced neutral thermal sensations was 13,4°C. This temperature was, therefore, considered to be the preferred indoor temperature. It approximated to that found by *Lugg* (1965) at a similar latitude.

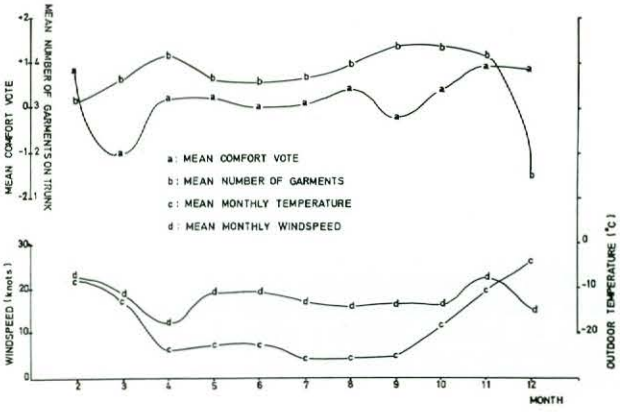

Fig. 2. Mean monthly values for: outdoor temperature; windspeed; outdoor comfort vote (trunk); and number of garments worn on the trunk outdoors.

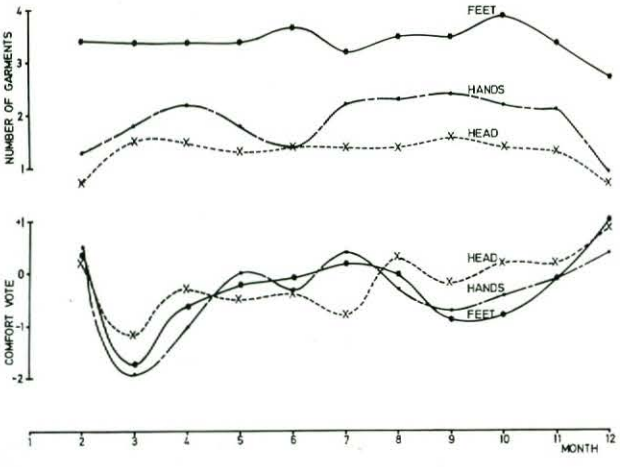

Fig. 3. Mean monthly values for the number of garments worn on the head, hands and feet outdoors and the relevant outdoor comfort votes.

As far as acclimatization to cold was concerned, the degree of comfort and the number of garments worn, and recorded by 12 members at a room temperature of 17°C during the months before midwinter, were compared with the data obtained at the same indoor temperature during the months after midwinter (Table 3).

To remain comfortable fewer garments were worn after than before midwinter. There is a trend in the fewer garments worn after midwinter which suggests some degree of adaptation to cold.

Outdoors.—The mean comfort-assessment and the number of garments worn, not only on the trunk as with the indoor survey, but also on the head, the hands and the feet, are shown in Figures 2 and 3. The mean monthly temperature and wind velocity at Sanae base are also shown in Figure 2.

During the first three months in Antarctica (February-April) the men gradually increased the amount of their clothing when working outdoors and then decreased it to a constant level during May, June and July. This level was, however, higher than that of February, similar to that of March and lower than that of April. From August onwards there was a general increase in the amount of clothing worn, which only decreased substantially in December.

The results obtained in March and April were interesting. There was only a small increase in the amount of clothing worn on the trunk and hands in March. Apparently this was not enough to compensate for the increased wind-chill the men were exposed to, and most of the men reported severe cold-discomfort. By April the amount of clothing worn had been increased sufficiently to produce greater comfort on all parts of the body.

In the months September to November the men dressed not only for the cold to which they were exposed, but also for the occasion. Many hours were spent riding on tractor-drawn sledges, which involved little physical activity. To keep warm and comfortable the men put on more clothing. The overall picture gained from the above findings is that as time passed the men became more experienced and learnt how to attain maximum comfort.

The observations of *Lugg* (1965), *Frazier* (1945) and *Butson* (1949), that the men maintained a higher level of comfort with no or little additional clothing, in spite of decreased temperatures with the onset of winter, are only partly confirmed in this study.

The present study indicates that, although the average monthly temperatures dropped from −12,4°C in March to −22,5°C in May, the amount of clothing worn remained constant and that in May a higher level of comfort was achieved (Figure 2). It appears that the

increase in the amount of clothing during March and April, and the varying levels of comfort associated therewith might indicate a period of adaptation. This increase in the amount of clothing worn was also associated with a steady decrease in the subscapular skinfold thicknesses (*Loots et al*, 1969).

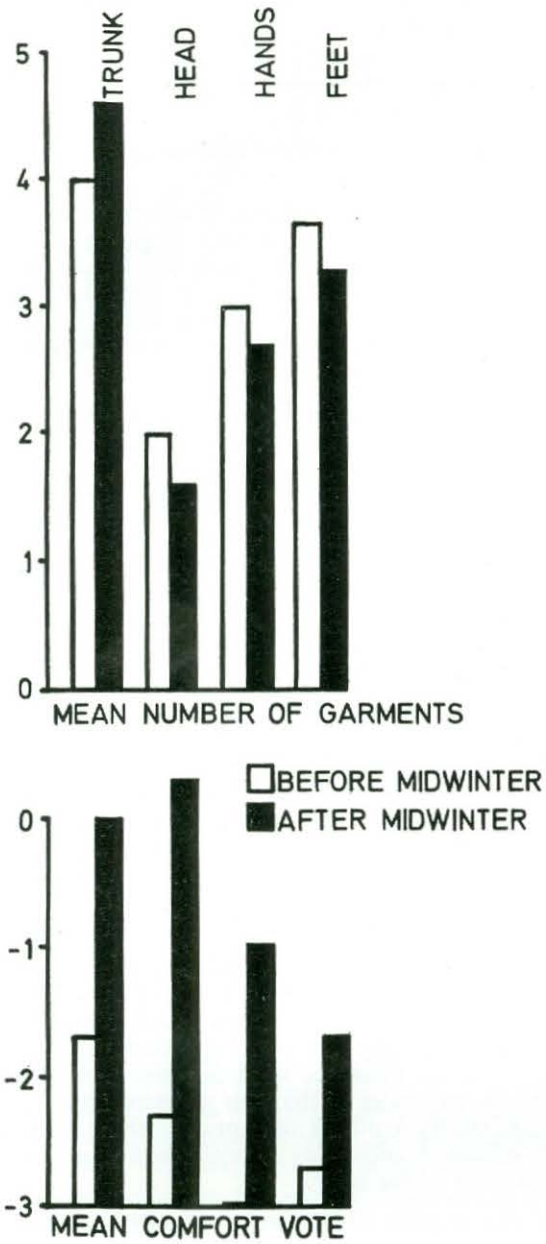

Fig. 4. A comparison of the mean comfort vote and the mean number of garments worn on the trunk, head, hands and feet in March and in September by a three-man geological team.

Palmai (1962) and *Goldsmith* (1960) observed that their subjects dressed appropriately for the outdoor conditions to which they were exposed. The men at Sanae base, having learnt from previous experience, dressed more suitably for the conditions to which they were exposed in the second half of the year than during the first few months spent at the base. This is especially true in respect of clothing for the trunk and hands. The clothing worn on the head and feet showed least variation throughout the year.

It is also clear from the results obtained in the second half of the year that the stimulus which induced

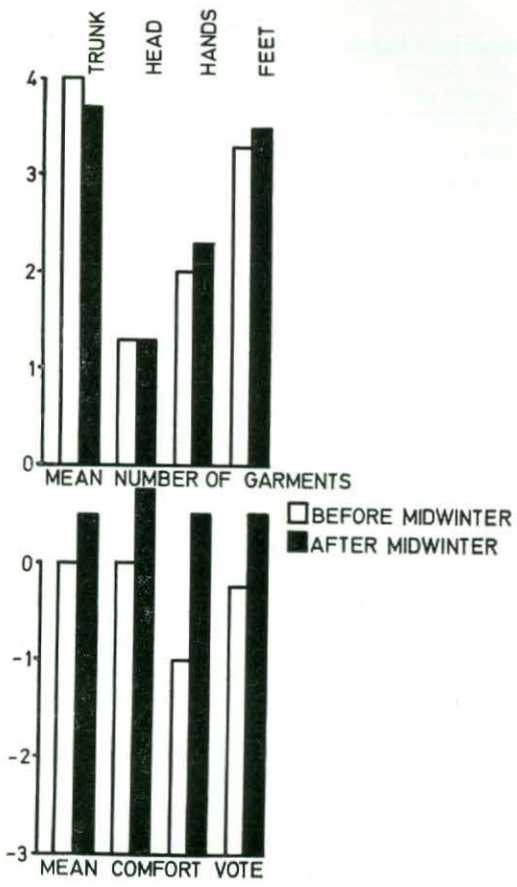

Fig. 5. A comparison of the mean comfort vote and the mean number of garments worn on the trunk, head, hands and feet in April and August by seven team members engaged in activities around the base.

them to add more clothing when ambient temperatures were low was greater than that which induced them to remove clothing when temperatures were higher. This was also remarked upon by *Goldsmith* (1960).

In order to determine whether any acclimatization to cold did occur further comparisons were made between the amount of clothing worn by a three-man geological team and the degree of comfort on days of equal wind-chill, before and after midwinter. On both occasions the subjects were engaged in similar activities, and were exposed to approximately similar weather conditions. In March the degree of *cold-discomfort* was high. Although the clothing worn on the two occasions was approximately the same for the same part of the body, the degree of general comfort was higher in September (Figure 4).

Similar results were obtained from seven members engaged in activities of identical nature in the vicinity of the base in April and August (Figure 5). The amount of clothing worn was virtually unchanged but the degree of comfort increased after midwinter. If one also considers the fact that the insulating value of the protective clothing worn outdoors decreased during the course of the year the results above suggest some degree of physical adaptation to cold.

This might support the observations of other workers (*Butson*, 1949; *Goldsmith*, 1960; *Lugg*, 1965) and of other acclimatization studies carried out on members of this (*Wyndham and Loots*, 1969) and other Sanae teams (*Wyndham et al*, 1964).

The fact that man is able to adapt to some degree to cold in polar regions has now been proved by many workers, using the simple techniques described above (*Goldsmith*, 1960; *Lugg*, 1965; *Palmai*, 1962), or more sophisticated methods (*Wyndham et al*, 1964; *Wyndham and Loots*, 1969). It remains to obtain more information on the mechanisms of man's adaptation to cold.

It has been shown that the adaptive changes to cold in man are mainly due to an increase in subcutaneous insulation (*Wyndham et al*, 1968; *Wyndham et al*, 1964; *Wyndham and Loots*, 1969). Whether an increase in such insulation is related to the amount of clothing worn or the degree of comfort attained has still to be established. Although the loss of subcutaneous fat during the months February to April 1967, of the same members (*Loots et al*, 1969) corresponds with an increase in the amount of clothing worn and the degree of discomfort experienced during these three months, no final conclusions could be drawn from these observations.

Acknowledgements

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