Vol. 5: 83–90, 1995 | CLIMATE RESEARCH Clim. Res. | Published February 23

Comparison of traditional and manufactured cold weather ensembles

Jill Oakes[1, 2], Heather Wilkins[3], Rick Riewe[2, 4], Doug Kelker[5], Tom Forest[6]

[1]Department of Native Studies, University of Manitoba, Winnipeg, Manitoba, Canada R3T 2N2
[2]Canadian Circumpolar Institute, University of Alberta, Edmonton, Alberta, Canada T6G 2J6
[3]Department of Physical Education & Sport Studies, University of Alberta, Edmonton, Alberta, Canada T6G 2H9
[4]Department of Zoology, University of Manitoba, Winnipeg, Manitoba, Canada R3T 2N2
[5]Department of Statistics and Applied Probability, University of Alberta, Edmonton, Alberta, Canada T6G 2G1
[6]Department of Mechanical Engineering, University of Alberta, Edmonton, Alberta, Canada T6G 2G8

ABSTRACT: Inuit elders stress the importance of wearing caribou skin clothing for winter trips. Although laboratory tests for thermal insulation values of clothing are extensive, caribou skin clothing is rarely tested. The purpose of this research was to compare the thermal comfort of caribou skin clothing, military winter issue clothing, and northern expedition clothing using experimental and ethnographic methods. To collect the experimental data, each subject wore the ensembles in an environmental chamber designed to simulate travelling on a sled pulled by a snowmobile in the Arctic winter. Skin temperatures and comfort ratings were analyzed using analysis of variance and multiple regression methods. Ethnographic methods were used to collect 'traditional' knowledge from Inuit elders. Findings indicate that the average skin temperature and comfort ratings dropped significantly less ($p < 0.05$) when wearing the caribou skin ensemble compared to changes observed when wearing the military or expedition clothing ensembles. There were no significant differences between the military and expedition clothing ensembles. Inuit elders use years of field experiences as a base for their recommendations to use caribou skin clothing for long-term protection for sedentary individuals exposed to a cold winter climate. They also point out the advantages of specific style features and materials for cold weather clothing. In conclusion, the combination of laboratory tests and traditional knowledge has given 2 distinct perspectives which provide a more holistic answer to cold weather clothing needs for people travelling during the Arctic winter.

KEY WORDS: Cold weather clothing · Inuit clothing · Skin clothing · Caribou clothing · Contemporary cold weather fabrics · Scientific and traditional knowledge · Thermal comfort

INTRODUCTION

Inuit elders continually stress the importance of wearing caribou (*Rangifer caribou* or *Rangifer tarandus*) skin clothing whenever travelling out 'on the land' in the fall, winter, or spring (Stefansson 1944, 1955, Angugatiaq 1973, Riewe 1975, Oakes 1987, 1991, 1992). Elders and Inuit seamstresses believe caribou skin clothing provides protection from extremely cold weather that is superior to fabric ensembles recommended for the Arctic by some manufacturers. Laboratory evaluations of thermal insulation values of clothing are extensive (Sprague & Munson 1974, Nishi 1975, McCullough & Jones 1983, 1985, McCullough & Rohles 1983, Zhu et al. 1985). However, caribou skin clothing has been omitted from such evaluations in the published literature, even though it is commonly used for winter clothing in the Eastern Canadian Arctic. A comparison of the thermal comfort of caribou skin ensembles and fabric clothing would be useful to help individuals select clothing for travelling in severe cold weather. The purpose of this research was to collect laboratory and ethnographic data on the thermal comfort of Inuit-made caribou skin clothing, military winter issue clothing, and expedition clothing produced for arctic travellers. The objectives were to identify which

winter ensemble provides the greatest protection against body cooling during dry, cold weather conditions using physiological measurements, and to identify which winter ensemble is perceived to provide the highest thermal comfort.

BACKGROUND LITERATURE

A review of the literature reveals elders' comments on the value of caribou skin clothing in anecdotal format collected using ethnographic and ethno-historical methods (Stefansson 1944, 1955, Angugatiaq 1973, Nelson 1973a, b, Riewe 1975, Oakes 1987, 1991, 1992). Inuit elders repeatedly state that caribou skin clothing provides the warmest and most comfortable protection against the cold arctic climate. The design features such as a hood, fur trim, dropped shoulder seams, pullover design, and ability of footwear, pants, parka, and mitts to interlock all provide excellent cold weather protection. These features combined with the physical properties of caribou skin provide the most effective cold weather clothing for extended periods in severe cold with no means of warming up or drying out. Inuit have used caribou skin clothing since pre-historic times and the styles are extremely well adapted to the climate (Oakes 1991, 1992).

A few references to fur insulation values are found (Newburgh 1949, Folk 1974). Most literature discussing thermal insulation values of clothing focuses primarily on fibres, fabrics, and finishes. Numerous scholars have studied the thermal insulation values of different types of fabric clothing and fabrics using laboratory evaluations (see Sprague & Munson 1974, Nishi 1975, McCullough & Jones 1983, 1985, McCullough & Rohles 1983, Zhu et al. 1985, Lotens & Havenith 1989).

METHODS

Men and women (50:50) of similar size from the academic community volunteered to participate in the experiment. Before beginning the experiment they gave written informed consent and were advised they could voluntarily withdraw at any time. For safety purposes, subjects were watched through a glass window and their core body and skin temperatures were monitored. A lower limit for skin temperatures (5°C) was established to prevent unnecessary discomfort. Each of the 12 subjects was measured for somatotype (Heath & Carter 1967), height, weight, and sum of skinfolds (Government of Canada Fitness and Sport 1987) (Table 1). Prior to each test, subjects completed a 24 h food recall and kept their diet and activity as consistent as possible. On separate days, subjects tested all 3 ensembles using a randomly assigned ordered sequence.

Experimental protocol. The experimental protocol consisted of (1) the collection of resting heart rate and skin and core temperature data for 10 min while wearing only T-shirt and shorts, and seated in a room at 21°C, 55% relative humidity (rh), (2) dressing in the clothing ensemble to be worn that day, and (3) sitting for 60 min in an environmental chamber at -28°C, 65 to 70% rh with a 20 km h^{-1} wind provided by fans. One hour was considered sufficient because previous experience with winter clothing demonstrated that within 30 min or less it becomes evident when hand or footwear is grossly inadequate in cold weather. Field experience has indicated that before an hour has passed, a thermal equilibrium is reached when wearing skin clothing in cold weather conditions (Stefansson 1944, 1955, Riewe 1975). Subjects were requested to role-play sitting on a snowmobile sled, as the cold chamber environment was designed to simulate travelling on a sled pulled by a snowmobile on a mild winter day ('mild' from the perspective of a seasoned winter traveller).

Skin (cheek, chest, thigh, toe, finger) and core [near-tympanic (ear)] temperatures (after Mitchell & Wyndham 1969, Nielsen & Nielsen 1984) were collected every 10 s using copper wire thermocouples and an Isothemex Electronic Thermometer (Columbus Instruments International Corporation, Columbus, OH, USA) with an IBM PC computer. Skin probes were taped to the skin and the same probe was always used for each measurement site. All probes were determined to be accurate within 0.1°C of a mercury thermometer from 0.5 to 45.0°C in a stirred water bath. Heart rate was recorded every 5 s throughout the experimental protocol with a Sport Tester PE3000 (Polar Electro Ltd, Kempele, Finland). The reliability and validity of these monitors was previously established (see Leger & Thivierge 1988). The subject's perception of overall and site-specific (cheek, torso, and toe) comfort ratings

Table 1 Values for age, height, weight, skinfolds, body type (endomorphy, mesomorphy and ectomorphy) were calculated for each subject

Measurement	Mean	Standard deviation
Age (yr)	30.9	±10.7
Height (cm)	172.9	±9.0
Weight (kg)	70.8	±9.9
Sum of skinfolds (mm)	68.2	±21.0
Endomorphy (scale 1-7)	4.2	±1.1
Mesomorphy (scale 1-7)	5.4	±1.2
Ectomorphy (scale 1-7)	2.1	±1.5

were obtained every 20 min using the McGinnis thermal scale and a 7-point scale developed for the experiment (after Hollies 1977, Hollies et al. 1979). Subjects also completed a questionnaire at the conclusion of each experimental trial on the overall comfort and design of the ensemble they had just worn. Information collected from these open-ended questions was analyzed using descriptive statistics.

In addition, test methods similar to those used by Sprague & Munson (1974), McCullough & Jones (1983, 1985), McCullough & Rohles (1983), and Zhu et al. (1985) were used to evaluate thermal insulation values. Analysis of variance (ANOVA) and multiple regression methods were used to analyze the physiological and comfort perception data. Clothing type, body part, and time were analyzed using ANOVA with the individual as a blocking variable. Because of the change of ratings and temperatures over time, a regression model gave a clearer explanation of the rate of change.

Description of each ensemble. All garments and footwear were rated for use at −40°C (unspecified activity level and conditions). Subjects wore the same cotton/polyester underwear, wool socks, cotton/polyester turtleneck shirt, and wool toque, under each ensemble. The caribou skin ensemble consisted of an inner and outer caribou skin hooded parka, caribou skin outer pants, caribou skin stockings worn inside seal skin boots, and caribou skin mittens. The hood was trimmed with dog fur. The ensemble was made from hand-scraped rather than commercially tanned skins taken from caribou killed in late August in the Arviat area of the Northwest Territories. The inner layer was worn with the caribou hair next to the subject's body, the outer layer was worn with the hair to the outside. The use of caribou skin boots would have increased the insulative value of the footwear. Both caribou and seal skin boots are used by Inuit while travelling on the ice in winter. Caribou skin boots and overslippers are usually preferred for extremely cold weather (below −40°C).

The expedition ensemble (provided by Blue Skys Ltd) included an inner and outer hooded parka, pants, wind pants, and mittens. Each item consisted of 4 layers: a nylon lining, open mesh nylon interlining, 6 mm layer of Thinsulate®, and a Gortex® nylon outer layer. This was a specially made ensemble for arctic travel. Rubber-soled boots (commonly called 'Army Mukluks' or 'Skidoo Boots') with white, nylon leg sections and lace-up closures were worn with composite liners (provided by Kauffman).

The 1991 arctic winter Canadian military ensemble (provided by the Department of National Defence) included an inner and outer hooded parka, pants, wind pants, and mittens. The inner and outer pants were made from uncoated nylon canvas outer shell with an inner layer of Polargard® (100% polyester) and a layer of Dermoflex® (coated fabric) lined with Nomex® (a plain-weave natural-coloured fabric). The parka (outer layer) and jacket (inner layer) were made from coated fabric (Dermoflex®) and lined with Nomex®. The parka also had a Polargard® (100% polyester) insulation layer. Mitts, made of the same layers as in the parka, and 'Army Mukluks' completed this ensemble.

Ethnographic methods. Ethnographic methods were used to collect traditional knowledge on effective Arctic winter clothing. Inuit elders were informally interviewed and different types of clothing ensembles were used while travelling 'on the land' and participating in winter games.

RESULTS

There were no significant differences ($\alpha = 0.05$) in changes over time between the military and expedition clothing ensembles with either the perception of comfort data or the skin temperature data; therefore, these data are grouped together. Average skin temperature was calculated as a weighted average of all skin temperature sites. Findings indicate that the overall skin temperature, as well as the cheek, thigh, toe, and torso temperatures, remained significantly higher ($p < 0.05$) when wearing the caribou skin ensemble compared to changes observed when wearing the military or expedition clothing ensembles (Fig. 1). Perceived comfort ratings for the feet area dropped over time for all ensembles; however, the feet area for the caribou skin ensemble was still rated warmer than the military and expedition ensembles. If caribou skin boots had been used instead of seal skin boots the toe temperature rating might have been significantly higher. Finger temperatures were not significantly different. Measured perceptions of comfort displayed the same patterns as the measured skin temperatures (Figs. 1 & 2).

Under the test conditions there was no significant difference in heart rate or near-tympanic temperature with time or experimental protocol, nor any interaction between time and experimental protocol. Neither was there any difference at rest or during the first measurement (0 min) for all the temperature measurements taken. This indicates that all ensembles were providing similar thermal protection at room temperature 10 min before entering the cold chamber and immediately after entering the cold chamber. From 10 min after the experiment began until the end of the experiment the overall average for all temperature measurements indicated caribou skin clothing was significantly warmer ($p < 0.05$) than the expedition and military clothing. Although there may be significant differ-

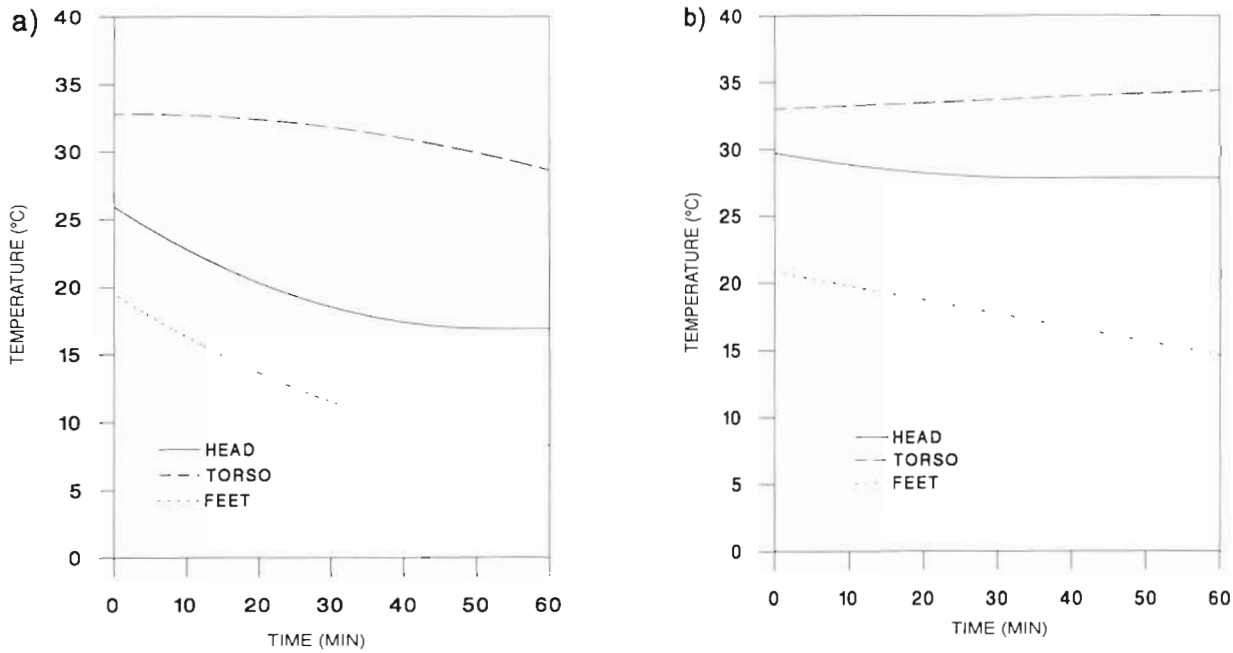

Fig. 1. Summary of skin temperature measurements for the head (cheek), torso (chest), and feet (toes) regions plotted against time while using (a) military and expedition ensembles and (b) the caribou skin ensemble

ences in skin blood flow between women and men (Krog & Wika 1978), there were no significant differences between men and women in any of the data. Neither was there a significant difference between the data collected for individuals of different ages or ethnicity. This may be a result of the subjects living a similar lifestyle (academics) and experiencing similar levels of acclimatization.

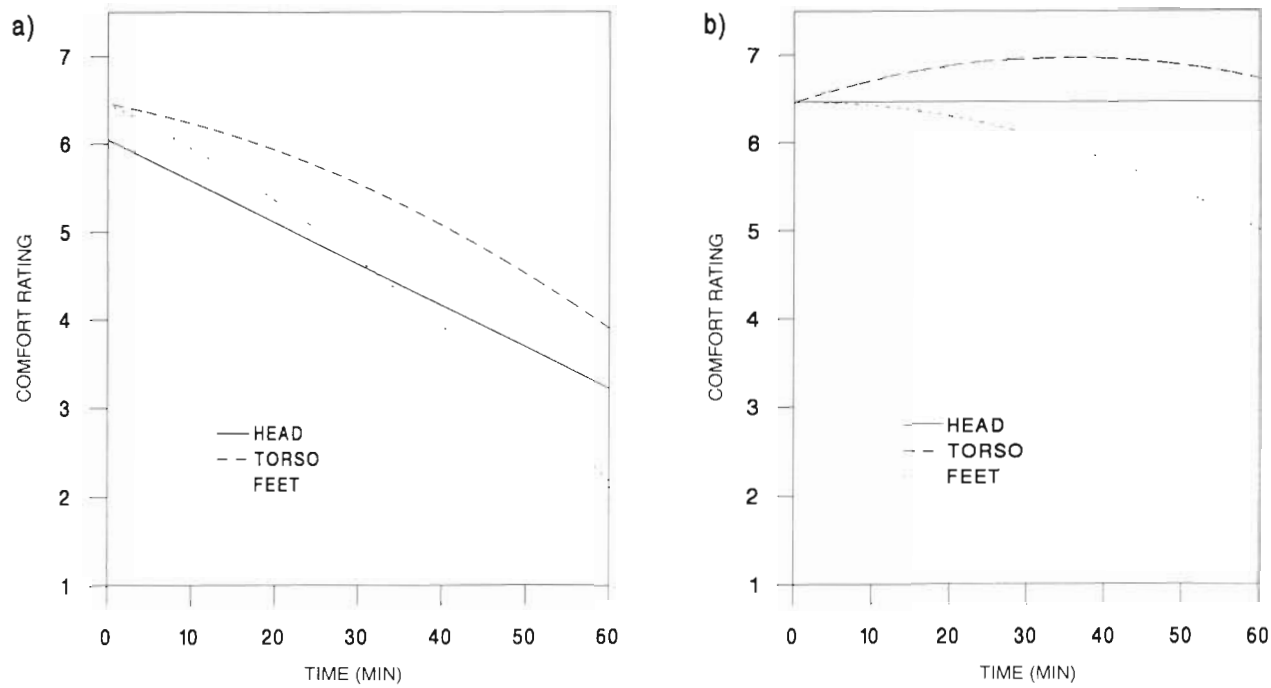

Fig. 2. Summary of comfort perception responses from 7-point scale (7 indicates comfortable, 1 indicates uncomfortable) plotted against time for the head, torso, and feet regions while using (a) military and expedition ensembles and (b) the caribou skin ensemble

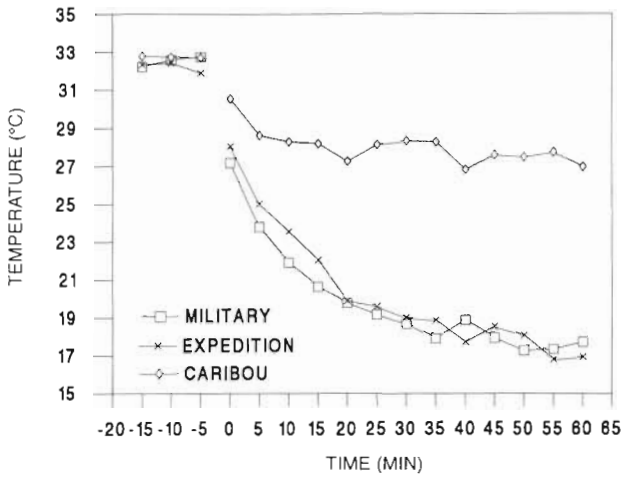

Fig. 3. Summary of cheek temperatures for subjects wearing each of the 3 ensembles: military, expedition, and caribou skin

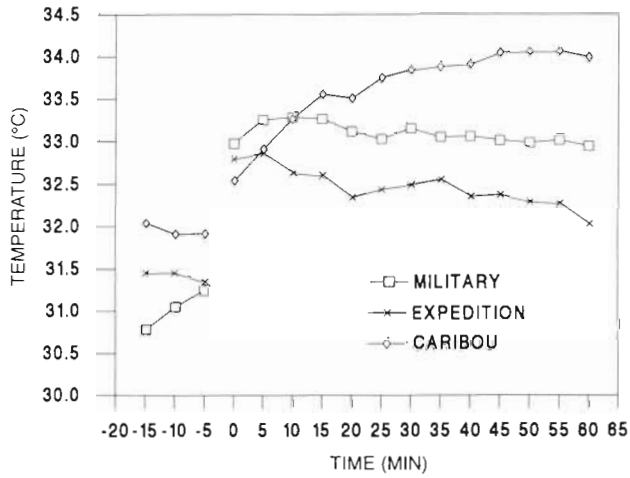

Fig. 4. Summary of chest temperatures for subjects wearing each of the 3 ensembles: military, expedition, and caribou skin

The cheek skin temperature (Fig. 3) indicated that there was no difference between subjects wearing each of the 3 ensembles at rest immediately prior to beginning each test. After 15 and 20 min in the cold chamber there was significant cooling of subjects' cheeks when they wore either the military or the expedition ensemble. This cooling trend continued for both of these ensembles. When subjects wore the caribou skin ensemble cheek temperatures were relatively stable, dropping only 2 to 3°C. This significant difference may be attributed to the hood style and fur ruff on the caribou skin parka. Caribou Inuit elders recommend using a hood that fits loosely around the back of the head and closely to the face. This enables the hot air to rise from the torso into the hood where it escapes around the face, keeping the face (including the cheeks) warm without wearing a scarf. Scarves, balaclavas, and other face masks are not recommended by Inuit elders because they trap body moisture which quickly freezes, forming an icy mask next to the face (Riewe 1975). Hoods are trimmed with wolverine *Gulo luscus*, wolf *Canis lupus*, or dog *Canis familiaris* fur (the parka used in the experiment was trimmed with dog fur). Inuit explain that these furs have irregular hair lengths which help to break the wind, creating a calm micro-environment around the face and reducing the chilling effect in cold weather environments (see also Riewe 1975, Oakes 1991). The individual comfort perception data indicate that the comfort rating (7-point scale) for the head was significantly higher ($p < 0.05$) when wearing the caribou ensemble (6.46) than the military (6.05) or expedition (6.05) ensembles.

The chest skin temperatures increased when subjects wore the caribou skin ensemble (Fig. 4) compared to the military or expedition ensembles. This suggests thermal stress or overheating rather than thermal insulation. However, seasoned northern travellers would add the second layer of their caribou skin parka during inactive periods and in extremely cold weather (–40°C) rather than at –28°C. Although the military and expedition ensembles were rated at –40°C they were uncomfortably cold at only –28°C.

Finger temperatures showed significant cooling for each ensemble tested beginning from 10 to 20 min after entering the cold chamber (Fig. 5). To keep bare hands warm without any physical movement at extremely cold temperatures might be impossible even if they were inserted into a 45 gallon drum filled with down (Stefansson 1944, Newburgh 1949). Inuit maintain warm fingers and toes by moving their arms and

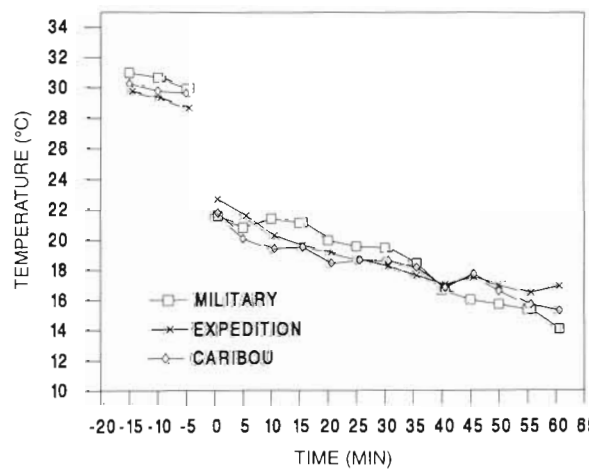

Fig. 5. Summary of finger temperatures for subjects wearing each of the 3 ensembles: military, expedition, and caribou skin

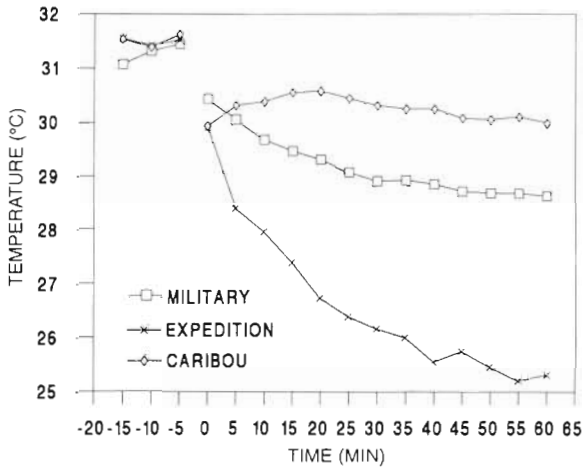

Fig. 6. Summary of thigh temperatures for subjects wearing each of the 3 ensembles: military, expedition, and caribou skin

legs, and pushing against another person until their extremities begin to become warm. This type of behavioral thermoregulation was not allowed in this experiment.

The caribou skin ensemble maintained the initial thigh temperature throughout the experiment. The thigh temperature on subjects wearing the military ensemble dropped significantly after 20 min in the cold chamber (Fig. 6). Thigh temperatures dropped significantly after only 5 min for the expedition ensemble. The differences in lag times for the military and expedition ensembles reflect significant differences in insulation provided by these 2 wind pants.

Toe temperature became uncomfortable (15°C) after 20 min for the expedition and military boots (Fig. 7). Toe temperature inside the caribou skin footwear

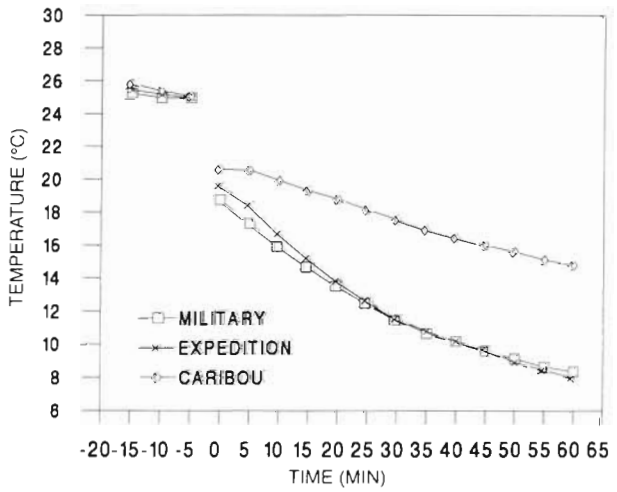

Fig. 7 Summary of toe temperatures for subjects wearing each of the 3 ensembles: military, expedition, and caribou skin

dropped slightly after 15 min and was uncomfortable after 55 min. After 60 min, toe temperatures had cooled to 9°C for the military and expedition ensembles and 15°C for the caribou skin ensemble. This trend illustrates the problem encountered when attempting to keep the extremities warm while sitting in cold weather conditions. The drop in average skin temperature when wearing caribou skin clothing averaged only 2°C. This reflects a drop in finger and toe temperatures, as the chest skin temperature actually increased. In contrast, the average skin temperature dropped 6°C when wearing the military and expedition ensembles. This reflects a drop in all skin temperature measurements. During field research, double layers of caribou skin parkas and pants plus 4 layers of caribou footwear provided thermal protection that enabled 2 subjects to sleep outside without shelter, on the snow surface, at −40°C on a calm night. Overall, caribou skin clothing provides more thermal protection than an igloo. For example, igloo temperatures (3.2 m diameter with 5 people and their bedding) drop 12°C between midnight and 09:00 h when the average outside temperature is −35°C (M. Waszkiewicz pers. comm. 1992). Similar findings were recorded by Elsner & Pruitt (1959) in Athapaskan quinzhees or snow shelters constructed from powdered snow.

Open-ended questionnaires provided subjects with an opportunity to reflect on each experimental trial experience. For example, subjects recorded that their feet never or rarely got cold wearing caribou skin footwear; however, they felt their feet were so cold they could hardly walk when they wore the expedition and military footwear. In addition to thermal comfort, other factors including design, colour, and ethical considerations were mentioned in the open-ended questionnaires. The fabric garments were considered stiff, crinkly, easily replaced, uniform in appearance, familiar in design, and uncomfortable in the cold. The blue colour of the expedition ensemble was preferred. Most found the caribou skin ensemble pull-over style awkward and slightly claustrophobic. Numerous people mentioned that they were unaccustomed to the gentle odour of animal hair, the bulkiness of the caribou clothing, and shedding caribou hair. Caribou skins are also susceptible to damage from heat, dampness, insect infestations, and from dogs chewing on it. Although they often used 'cozy' to describe the caribou clothing, some subjects found the fur ruff irritating next to their face. Some subjects found the use of animal skins unacceptable in clothing for ethical reasons. Others found the use of skins more environmentally sensitive than using fabrics made from petroleum products and dyed with substances that leave toxic wastes. Ease in maintenance was observed by some while wearing the caribou skin clothing; local products

are used without fasteners to replace or fix. Some subjects mentioned the difficulty of purchasing caribou skin clothing for large numbers of people, such as military personnel and outdoor enthusiasts. This is supported by Hedblom (1965) who felt the exceptional skills needed to make skin clothing made it difficult to acquire. Cost was not a factor as the ensembles were of approximately the same monetary value.

CONCLUSIONS

Inuit elders indicate that Inuit-designed caribou skin clothing is the most effective cold weather clothing for extended periods in severe cold with no means of warming up. Elders continually remind people to bring their skin clothing with them even if they are just going out for a short snowmobile or all-terrain vehicle ride. Accidents happen each year where 1 or 2 people perish from the cold due to being stranded a mile or two from the community when an unusual storm comes up quickly and they are inadequately dressed. The laboratory data support the recommendations of Inuit elders to use caribou skin clothing for long-term protection for sedentary individuals exposed to a cold winter climate. Caribou skin clothing is warmer than the clothing ensembles tested; however, it is not necessarily better for active users. There was no significant difference between the military and expedition ensembles in their comfort and insulation properties; however, the caribou skin ensemble was significantly warmer under the test conditions. One limitation of clothing tests is that the clothing combinations selected may not accurately reflect the clothing actually chosen for specific activities. For example, individuals might select a combination of Inuit, military, and mass-produced expedition clothing to meet their own needs.

Physiological measurements and perceived comfort ratings illustrated the same temperature trends for each garment and for the head, torso, and toes. All areas had higher skin temperatures and perceived comfort ratings with the caribou skin ensemble than with either the military or expedition ensembles. However, for all these ensembles, the extremities (feet and hands) were not kept as warm and comfortable as the torso and thigh areas. None of the garments tested would keep an individual warm indefinitely while riding on a sled in cold winter temperatures; however, the caribou skin ensemble was most effective for these conditions.

The combination of laboratory tests and traditional knowledge provides 2 invaluable, distinct perspectives. The result is a more holistic analysis of cold weather clothing needs. In each Arctic region Inuit use different styles, materials, and techniques to produce their clothing. Future research is needed to compare skin temperatures and perceived comfort ratings of the diverse array of clothing styles used across the Circumpolar Arctic. Additional research is also needed to compare traditional designs made with modern materials.

Acknowledgements. Corinne Butt, Dave Fortin, Patrick Fradin, Gaby Kienitz, Mors Kochanski, Bruce Miller, John Nishi, Brian Oakes, Adair Patterson, Paulo Riess, Karen Robbins, and an anonymous subject are thanked for volunteering to participate in this experiment. Inuit elders, hunters, and seamstresses are thanked for providing an invaluable perspective to this study. Drs Betty Crown, Doug Dale, Larry Wang, Harvey Scott, and Wally Cottle are thanked for their valuable help in the planning phases. Brent Purnell and Helena Perkins are thanked for their lab support. The Department of Physical Education and Sport Studies is thanked for access to their cold chamber. Kauffman Ltd, Blue Skys Ltd, and DREO, Department of National Defense, are thanked for providing garments for the experiment. Information supplied by Dawn Carrick and financial support from the University of Alberta Small Faculties Research Funds are gratefully acknowledged. Anonymous reviewers are thanked for their comments on the manuscript.

LITERATURE CITED

Angugatiaq M (1973) Caribou garments. Inummarit 2(1):6

Elsner R, Pruitt W Jr (1959) Some structural and thermal characteristics of snow shelters. Arctic 12:20–27

Folk G (1974) Environmental physiology. Lea and Febiger, Philadelphia

Government of Canada Fitness and Sport (1987) Canadian standard tests of fitness operations manual, 3rd edn. Minister of Supply and Services Canada, Ottawa

Heath B, Carter J (1967) A modified somatotype method. Am J phys Anthropol 16(5):57–74

Hollies N (1977) Psychological scaling in comfort assessment. In: Hollies N, Goldman R (eds) Clothing comfort: interaction of thermal, ventilation, construction and assessment factors. Ann Arbor Science Publishers, Ann Arbor, MI, p 107–129

Hollies N, Custer A, Morin C, Howard M (1979) A human perception analysis approach to clothing comfort. Textile Res J October: 557–564

Krog J, Wika M (1978) Studies of hand blood flow of the Igloolik Eskimos. Med Biol 56:148–151

Leger L, Thivierge M (1988) Heart rate monitors: validity, stability, and functionality. Physician Sports Med 16(5): 143–151

Lotens W, Havenith G (1989) Calculation of clothing insulation and vapour resistance. TNO report IZF 1989–49, TNO Institute for Perception, Soesterberg

McCullough E, Jones B (1983) Measuring and estimating the clothing area factor. Institute for Environmental Research Technical Report 83-02. Kansas State University Press, Manhattan

McCullough E, Jones B (1985) A comparison of methods for estimating clothing insulation. Proceedings of CLIMA 2000, World Congress on Heating, Ventilation, and Air Conditioning, 4 (August), Copenhagen, p 71–76

McCullough E, Rohles F (1983) Quantifying the thermal protection characteristics of outdoor clothing systems. Human

Factors 25(2):191–198
Mitchell D, Wyndham C (1969) Comparison of weighting formulas for calculating mean skin temperature. J appl Physiol 26(5):616–622
Nelson R (1973a) Hunters of the northern ice. University of Chicago Press, Chicago
Nelson R (1973b) Hunters of the northern forest. University of Chicago Press, Chicago
Newburgh L (1949) Physiology of heat regulation and the science of clothing. WB Saunders Company, Philadelphia
Nielsen R, Nielsen B (1984) Measurement of mean skin temperature of clothed persons in cool environments. Eur J appl Physiol 53:231–236
Nishi Y (1975) Direct measurement of clothing heat transfer properties during sensible and insensible heat exchange with thermal environment. ASHRAE Transactions 81: 183–199
Oakes J (1987) Factors influencing skin boot production in Arctic Bay, N.W.T MSc thesis (1985), University of Manitoba. Canadian Museum of Civilization Mercury Series. Can Ethnol Serv Pap 107:1–54
Oakes J (1991) Copper and caribou Inuit skin clothing production. PhD dissertation (1988), University of Manitoba. Canadian Museum of Civilization Mercury Series. Can Ethnol Serv Pap 118:1–277
Oakes J (1992) Factors influencing Copper and caribou Inuit skin clothing. Dress 19:41–56
Riewe R (1975) A lesson on winter survival from the Inuit. Manitoba Nature 16(4):24–33
Sprague C, Munson D (1974) A composite ensemble method for estimating thermal insulating values of clothing. ASHRAE Transactions 80(1):120–125
Stefansson V (1944) Arctic manual. Macmillan, New York
Stefansson V (1955) Clothes make the Eskimo. Natural History 64(1):32–41
Zhu X, McCullough E, Jones B (1985) Thermal insulation of layered Chinese clothing. ASHRAE Transactions 91(2): 493–505