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ENERGY EXPENDITURE OF INFANTRY PATROLS DURING AN ARCTIC WINTER EXERCISE

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ABSTRACT

The energy expenditure of infantry troops participating in winter training exercises at Churchill and Frobisher Bay was monitored. Twenty-seven personnel comprising three tent groups were studied as they carried out the normal tasks of living in tents and moving on foot. At Churchill, where mechanical transport and laboratory facilities were available, direct measurements with the Kofranyi-Michaelis respirometer were obtained as the personnel carried out their training assignments including cross country patrols up to 6000 metres a day. At Frobisher Bay close observation and diaries were used to assess the energy expenditures of the same personnel. A gross energy cost of 3484 Kcal per man per day was calculated from these data. The ration provided 3600 Kcal, enough to maintain caloric balance although there were significant changes in body composition.

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INTRODUCTION

An operational requirement to determine the optimum and minimum caloric needs for military activity in temperate and Arctic environments has been stated. This report deals with the energy expenditure of CF military personnel engaged in training exercises during February and March 1973 operating out of Fort Churchill, Manitoba. These training exercises are part of Exercise New Viking during which company-size units of approximately 100 military personnel spend two weeks learning to live, work and travel as a functioning military organization in the Arctic and sub-Arctic environment. A typical exercise consists of spending the first week in the Churchill area and the second week in a remote area, in this case near Frobisher Bay on Baffin Island, N.W.T.

Living accommodation consists of 10-man Arctic tents and travel is on foot, with or without snowshoes, with each man carrying his personal back pack and weapon. The remainder of the equipment is pulled on a metal toboggan which, when loaded with tent, fuel, stoves and two days food, weight approximately 350 lbs. A toboggan team consists of three men, one behind the toboggan steering and two in a tandem harness pulling in front. Each man also carries his own pack and weapon, totalling some 50–60 lbs and takes a regular turn on the toboggan team.

The terrain at Churchill was generally level, consisting about equally of frozen lakes and tundra. The snow was hard packed, six to 12 inches deep except where it had drifted to three feet. At Frobisher the terrain was rocky and hilly and movement was generally restricted to the valleys. In most cases the snow surface would sustain a man with pack when he was wearing snowshoes. When patrols were undertaken the rate of progression varied from 2000 metres per hour to 3600 metres per hour depending on terrain and weather. Equipped as described above, traversing 100 metres involves about 130 paces without snowshoes, 150 paces with snowshoes.

The daily environmental temperatures ranged from $-38^{\circ}F$ to $+7^{\circ}F$ (mean of $-20^{\circ}F$) with wind velocities producing windchill values from 1550 to 2160 $Kcal/m^2/hr$.

METHOD AND MATERIALS

The subjects were 27 infrantrymen (three tent groups) ranging in age from 19 to 37 years (mean 23 years) participating in the training exercise. The energy-expenditure measurements were taken with a standard Kofranyi-Michaelis respirometer in an insulated case with a modified harness which enabled it to be attached to the military back pack. Notwitstanding the insulated case, it soon became apparent that the device would operate reliably for only short periods. During actual use, an observer accompanied the subject wearing the respirometer, usually pace for pace, to ensure that the mouthpiece and noseclip were properly in place. This method also permitted the observer to detect icing of the inlet valve of the mouthpiece before the subject suffered any restriction to ventilation. Because of these problems collection periods were usually 15 minutes or less. These periods were timed by stopwatch carried by the observer, who also recorded the ventilation volume. Following each collection period the contents of the aliquot bag were immediately transfered to lubricated 100 ml glass syringes and stored in wooden cases inside an armoured personnel carrier (APC) which accompanied the observers during these periods.

At the conclusion of a day's activities on the trail, the APC returned the observers and gas samples to base. After temperature equilibration, the expired gas was analyzed for concentration of oxygen and carbon dioxide using Beckman paramagnetic and infrared analyzers respectively. Duplicate gas samples were passed through the analyzers and concentrations recorded. The analyzers were calibrated with a standard gas (3% CO_2 and 18% O_2) and ambient air after every second sample. Barometric pressure readings were obtained daily from the local meteorological office.

The procedure outlined above was used at the Churchill location only. Lack of an APC or equivalent at the Frobisher Bay location prevented such precise measurements. However, the daily diary was continued throughout the second week, providing a record of time, distance and daily activity. This record permitted an extrapolation to be made of the first-week data using an arbitrary correction of +14% to account for the greater speed of movement as the patrol moved to the interior of the island.

RESULTS AND DISCUSSION

The energy expenditure of three tent groups (27 men) was measured as they participated in a New Viking exercise. During these exercises the emphasis was on training, and learning the skills and techniques necessary to survive in the harsh environment. Cross-country movement was an important part of these exercises with 25000 metres being covered in the first week of the exercise. This was accomplished on foot carrying packs and pulling a 350 lb toboggan in stages up to 6000 metres per day at a rate of approximately 2000 metres per hour. During the second week a distance of 44000 metres was covered at rates as high as 3600 metres per hour.

The data from which the energy expenditure for the toboggan team was derived are shown in Tables 1, 2 and 3. It was accepted as fact by those with experience in toboggan pulling that the man in the centre, or the number 2 position, did more than one third of the work. Our data support this contention, the energy expenditure for this position being 10.39 Kcal/min compared with 8.60 Kcal/min for the other two positions. The conventional explanation for this difference is that because the first man is breaking trail and the third man is steering they will not always be able to contribute an equal effort toward the forward motion of the toboggan.

TABLE 1

Energy Expenditure of the Toboggan Team – Lead Position (Pulling)
(Data from 11 Subjects)

Ventilation L/min	Expired Gas Analysis		O_2 Consumption L/min	KCal/min
	% CO_2	% O_2		
41.9	4.00	15.8	2.15	10.75
65.0	4.02	16.10	3.13	15.65
35.7	2.62	17.45	1.24	6.20
26.5	2.31	18.10	0.75	3.75
28.7	4.95	14.75	1.77	8.85
23.1	3.60	16.30	1.06	5.30
46.9	4.03	16.60	2.03	10.15
46.0	4.36	16.1	2.22	11.1
41.4	4.10	16.25	1.93	9.65
54.4	3.12	17.50	1.86	9.30
29.6	2.37	18.10	0.83	4.15

M = 8.62 + 3.52

TABLE 2

Energy Expenditure of the Toboggan Team – 2nd Position (Pulling)
(Data taken from 9 Subjects)

Ventilation L/min	Expired Gas Analysis		O_2 Consumption	KCal/min
	% CO_2	% O_2	L/min	
50.7	4.22	15.55	2.72	13.60
74.2	4.02	16.10	3.58	17 90
39.9	2.95	16.95	1.58	7.90
24.4	4.40	15.8	1.25	6.25
21.1	3.55	16.8	0.87	4.35
31.8	4.30	16.4	1 44	7 20
64.8	5.08	15.25	3.68	18 40
36.4	4.57	16.15	1.81	9.05
36.0	4.10	16.10	1.77	8.85

M = 10.39 ± 5.06

TABLE 3

Energy Expenditure of the Toboggan Team – 3rd Position (Steering)
(Data from 8 subjects)

Ventilation L/min	Expired Gas Analysis		O_2 Consumption	KCal/min
	% CO_2	% O_2	L/min	
49.2	4.00	15.8	2.52	12.60
30.7	3.70	16.4	1.39	6.95
32.1	2.83	17.45	1.11	5.55
23.9	4.10	15.7	1.20	6.00
36.7	4.75	16.1	1.77	8.85
54.5	4.50	15.95	2.71	13.55
40.2	5.16	15.4	2.22	11.1
27.9	3.30	16.7	1 18	5.90

M = 8.81 ± 3.22

Table 4 shows representative data for "marching" on the trail under the same conditions but not as part of the toboggan team. The mean value of 4.83 Kcal/min. compares with the mean value of 9.27 Kcal/min. for toboggan pulling. Representative activities involved with tent routine were also sampled producing a mean value of 4.00 Kcal/min whereas measurements during the "leisure" time in the tent yielded a mean value of 1.75 Kcal/min. No attempt was made to measure the energy expenditure during sleeping periods. A value of 1.28 Kcal/min based on 0.67 Kcal/min/m^2 of body surface (1 91 m^2 mean value) was used.

TABLE 4

Energy Expenditure Patrolling – Pack + Snowshoes
(Data from 9 subjects)

Ventilation L/min	Expired Gas Analysis		O_2 Consumption	KCal/min
	% CO_2	% O_2	L/min	
31.9	2.3	17.6	1.06	5.30
37.2	1.78	18.3	0.98	4.90
31.9	5.35	15.8	1.63	8.15
26.2	3.12	17.5	0.88	4.40
31.9	2.60	17.7	1.01	5.05
15.3	2.97	17.45	0.53	2.65
25.7	3.09	17.8	0.80	4.00
25.0	2.07	17.9	0.75	3.75
28.2	3.47	17.1	1.06	5.30

M = 4.83 ± 1.51

These data were combined with the data from the activity diaries to produce a chart of time and energy expenditure (Table 5). Mean daily expenditure of 3358 Kcal at Churchill and 3611 Kcal at Frobisher Bay combine to produce a daily mean expenditure of 3484 Kcal for the two five-day periods of cross-country movement. The greater distance covered and the faster rate of travel during the second week with a consequent higher energy expenditure was offset by a reduction of time spent at tent routines. This may be partly attributed to day's-end fatigue but it also reflects greater organization and efficiency with less time required to accomplish the necessary tasks. The net result is an almost equal daily energy expenditure for the two periods.

For these conditions where shelter, food and fuel are moved manually on toboggans by the infantry without mechanical support, the energy cost per mile becomes important. Table 6 summarizes the energy cost data for this exercise, showing values of 293 and 253 Kcal per man per mile for the two phases of the operation. At Frobisher Bay where the average distance covered per day was approximately 5.5 miles the cost of the actual patrolling becomes 1381 Kcal per day whereas the cost at Churchill was 909 Kcal per day.

As shown in Table 5, however, the total energy costs per day were similar, 3611 Kcal and 3358 Kcal respectively for the two phases with a mean value of 3484 Kcal. To meet this requirement a daily ration of approximately 3600 Kcal is issued. If the unmeasured fecal, urinary and respiratory losses are taken to be 150 Kcal daily the result is an apparent caloric balance during this exercise. This assumes that all the available calories were consumed. We did not attempt any sophisticated food balance study but we did collect and monitor garbage. (All discarded items are collected daily in any case and carried

forward until collection can be arranged.) Inspection revealed very little wastage, our estimate being 200 Kcal per man per day. The net result is a negative caloric balance of approximately 3000 Kcal per man for the exercise. This represents less than one half Kg of weight. We observed a gross mean weight loss of 1 Kg per man for the exercise.

Notwithstanding this small imbalance, there were significant changes in body composition as indicated by a decrease of 38% in mean skinfold thickness. This change represents a loss of 4.2 Kg of body fat for each man. It is not clear at this time whether these changes represent a replacement of body fat with lean tissue in response to the increased workload or whether this loss in subcutaneous fat resulted from mobilization and redistribution at other body sites. This concept will be investigated during forthcoming laboratory trials.

Table 5

Time and Energy Expenditure – Two Five-Day Patrols

	Activity	Mean Energy Equivalent KCal/hr		CHURCHILL (5 Days)		FROBISHER (5 Days)	
				Mean Hours for 5 Days	Total KCal in 5 Days	Mean Hours for 5 Days	Total KCal in 5 Days
PATROL		Churchill	Frobisher				
	Movement	378.6	431.6	12	4,543	16	6,906
	Rest	240.0	240.0	3	720	4	960
	Total			15	5,263	20	7,866
BIVOUAC	Work	240		12	2,880	6	1,440
	Leisure and Eating	105		53	5,565	54	5,670
	Sleeping	77		40	3,080	40	3,080
	Total			105	11,525	100	10,190
	Total for 5 Days			120 hrs	16,788	120 hrs	18,056
	Total KCal for 10 Days			34,844			
	Daily Energy Expenditure			3,358		3,611	
	Mean Daily Energy Expenditure on Patrol			3,484			

Table 6

Summary of patrol activity showing energy cost per hour and per mile at both locations.

Time, Distance, Rate and Energy Expenditure		(5 Days) Churchill	(5 Days) Frobisher
Trail Time (Hrs)	Moving	12	16
	Resting	3	4
	Total	15	20
Distance Covered	Meters	25,000	40,000
	Miles	15.5	27.3
Rate of Travel	Metres/hr	2,083	2,750
	Miles/hr	1.3	1.7
Energy Expended Moving on Trail	KCal/hr	378.6	431.6
	KCal/mile	293.1	253

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