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INVESTIGATION OF HEALTH PROBLEMS RELATED TO CANADIAN NORTHERN MILITARY OPERATIONS

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Some Canadian military operations dictate rapid deployment of mobile land elements from a temperate to a Northern environment and the subsequent deployment of small bodies of troops on operational patrols. Under these conditions, it is paramount to the successful accomplishment of the mission that the individual be protected maximally against environmental hazards and that his health and well-being be maintained. (U)

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INVESTIGATION OF HEALTH PROBLEMS RELATED TO CANADIAN NORTHERN MILITARY OPERATIONS

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INVESTIGATION OF HEALTH PROBLEMS RELATED TO CANADIAN NORTHERN MILITARY OPERATIONS

INTRODUCTION

This presentation is a status report on current research being carried out by members of the Biosciences Division of the Defence and Civil Institute of Environmental Medicine, Canada. The report is intended to provide background material and preliminary research data on a variety of health problems related to military operations in Canada's North.

The effective accomplishment of military operations and missions depends ultimately upon a high level of human performance. As embarrassment to the health of an individual can compromise his level of effectiveness, the maintenance of health in military forces is most essential, particularly where troops are required to operate under adverse environmental conditions. Indeed, history is replete with examples of military forces being decimated by the combination of poor health and severe climatic conditions.

In view of Canada's comitments in the North, a consideration of environment-related health problems becomes important. Though Northern operations involve all three branches of the Canadian Armed Forces, it is the land element which is most directly exposed to adverse climatic conditions for periods of greater than a few hours. Northern training of Canada's land element is predicated upon the concept of mobile, self-sufficient units being able to operate effectively at some distance from their base camps for varying periods of time. The present training is the responsibility of Mobile Command Headquarters and is designated exercise New Viking. This is a continuous ongoing program of instruction with winter headquarters at Churchill, Manitoba and summer headquarters at Resolute, Northwest Territories. Training revolves around the operation of 5- or 10-man tent groups, each tent having its own tent group commander. Each tent group is self-sufficient in that it transports its own tent, stoves, cooking utensils, food, and operational equipment. Transportation is by foot and equipment is sledged either by one man (5-man tent group) or three (10-man tent group). Because of the terrain and logistic considerations, skis have been found to be impractical and snowshoes provide the only assistance to the Canadian soldier, each man carrying his own pair. In addition, each man carries a rucksack, weighing 40-50 lbs, which contains specified items of clothing, personal kit, sleeping bag, and food. At all times, each man must carry on his person one survival ration and a one day's supply of field rations. Ration components are of both the tinned and dessicated variety. Water for consumption and reconstitution of dessicated foods is obtained by melting snow. This is a time-consuming, low-yield endeavour but is essential to the survival of the individual. The relative lack of potable water contributes significantly to the health problem of dehydration discussed below.

At the present time, Canada does not maintain an operational land element in the North. Hence, when a requirement arises, troops from Southern Canada are airlifted to the North to perform their respective tasks. This concept of a mobile armed force raises significant questions related to the effectiveness of troops transported suddenly from a temperate to an Arctic environment; with respect to the health of individuals, consideration must be given not only to the hazards of Arctic habitation *per se*, but also to the effect on the individual of acute environmental stress. Over the past year, DCIEM has been concerned specifically with defining the nature, incidence, and severity of health problems related to Northern Operations and with an investigation of problems of dehydration, cold injury, caloric requirements, and energy expenditure. This paper presents progress made to date in these problem areas.

EPIDEMIOLOGIC SURVEY

Both anecdotal and experimental reports have suggested that excursions into adverse environments may be accompanied by an increased susceptibility to a variety of infectious and allergic disorders (1,2,3,4). The frequency, though not necessarily the severity, of asthmatic attacks is reportedly increased upon exposure to low environmental temperatures (1) and episodic rheumatic disease has often been related empirically to cold exposure. A report by Russian observers in 1959 suggested that an unfavourable Arctic environment could cause past diseases to recur or to become exacerbated (5). On the other hand, absence of respiratory infection is commonly believed to be a characteristic of polar isolation. For example, surveys of health problems encountered in the French Antarctic stations indicated the virtual absence of infectious disease (6). Experiences in isolated communities of both the Arctic and Antarctic suggest that episodes of infectious disease are inversely correlated with the degree of isolation of the community. Each contact with the outside world introduces episodic infections which run their course and become extinct (7). In this regard, analysis of data reported by the Australian National Antarctic Research Expeditions from 1947-72 indicated that the periods of greatest illness were always associated with re-supply visits (8). Similar surveys at United Kingdom Antarctic stations showed that the overall incidence of colds was similar to that observed in other isolated communities but lower than that reported for rural or urban communities. During relief periods, the incidence of colds was seen to approach that observed in non-isolated populations and then to decline after the first month of winter isolation (9).

The majority of epidemiologic studies which have investigated environmental factors impinging on disease have been concerned with indigenous populations or isolated communities. Data derived from such studies are not applicable directly to transit populations such as Canadian Military mobile forces. Recognition of this fact prompted DCIEM to establish a protocol for obtaining epidemiologic data on troops making periodic excursions from a temperate to a Northern environment. The underlying questions were, "does the abrupt introduction of a man into the Northern climate produce any alteration in health pattern? If so, what is the nature of this alteration? "

An opportunity to examine these questions arose in the Spring of 1972 when a team of DCIEM scientists was invited to participate in a Canadian Forces subarctic exercise, Exercise Northern Ramble. Through liaison with the First Battalion, The Royal Canadian Regiment (1RCR), access to some 400 men was made possible. The nature, incidence and severity of health problems which appeared during the course of the exercise were assessed in four field companies through personal symptom cards (Figure 1), questionnaires relating to personal history, and Medical Corps records. Symptom cards were completed daily by each member of the Battalion. This procedure was initiated one week before commencement of the exercise and carried through to several days after redeployment to Canadian Forces Base London, Ontario (CFB London). During the in-field phase of the exercise, when the men were living under canvas, the tent group commanders retained all symptom cards and supervised their completion after the evening meal. A personal history questionnaire was administered to all personnel before and after the exercise period. Medical files of the exercise consisted of complete in-field observations by Medical Officers and Medical Assistants as well as sick-bay reports from both field and base medical support units.

Meteorological Data

Since the epidemiologic survey was intended to examine the effect of a modified environment on general body health, it was necessary to define precisely the actual environmental conditions of exposure during the exercise. The air temperature in London, Ontario at the time of departure ranged from 75 to 80°F (24 to 27°C) and upon arrival in Churchill, Manitoba was 27 to 32°F (-3 to 0°C). During the exercise period, air temperature and wind speeds, measured concurrently during daylight hours, ranged

	Date														
	Day of Week	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun
SYMPTOMS	Sneezes														
	Stuffy Nose														
	Running Nose														
	Throat Sore														
	Chest Cough														
	Head Aching														
	Body Tired/Aching														
	Chills or Fever														
	Nausea or Vomiting														
	Skin Rash														
	Feeling Thirsty														
	Feet Itching														
	Feet Sore														
	Feet Swollen														
	Indigestion														

Figure 1. *Daily symptom card used to record symptoms on a spring subarctic exercise (Exercise Northern Ramble). Symptoms were indicated as being ABSENT (-) or PRESENT, MILD (+) SEVERE (++).*

from 10°F (-12°C) and 4 MPH (windchill 800 kg cal/m^2/hr) to 57°F (14°C) and 4 MPH (windchill 400 kg cal/m^2/hr). Minimum night temperatures ranged from 6° to 31°F (-14 to 0.6°C) with a mean minimum temperature of 22°F (-6°C). Precipitation was negligible throughout most of the exercise. It is apparent from these recordings that very mild Northern weather was experienced. The mildness resulted in an early thaw so that much of the tenting and travel occurred under very damp conditions.

Against this climatic background, it became clear from the survey, that symptoms relevant to the well-being of individuals were influenced by movement from the Southern to the Northern environment. Table 1 and Figure 2 present representative data from one of the four field companies surveyed.* With the exception of nausea or vomiting, all symptoms surveyed demonstrated an increased frequency within 2-3 days after deployment from CFB London and a return toward baseline values towards the termination of the exercise. During the exercise, maximum frequencies could, in most cases, be related to periods of heightened activity.

TABLE 1

Percent Frequency of Symptoms Reported by Members of One Company (Alpha) of Troops on a Spring Subarctic Exercise (Exercise Northern Ramble)

Symptom	Exercise Locale					
	London Pre-Exercise	Churchill Base	Eskimo Point	Churchill Southern Advance	Churchill Concentration Area	London Post-Exercise
Nasal	15.6	39.5	57.4	50.4	34.3	12.9
Chest Cough/ Sore Throat	7.0	16.7	21.6	24.0	18.3	6.7
Chills/Fever	1.2	3.1	5.9	6.9	1.4	0
Headache	2.5	7.4	14.8	5.8	3.2	2.1
Thirst	0.8	4.9	10.5	14.8	4.6	1.0
Indigestion	0.8	11.1	19.4	11.1	9.1	1.0
Nausea/ Vomiting	0	0.6	0.9	1.0	0	0
Body Tired/ Aching	1.6	3.7	14.8	21.5	4.6	0.5
Foot Problems	0	0.6	5.9	8.4	1.7	0

* Companies were treated separately because of unique circumstances surrounding each. For example, time of departure and duration on exercise, geographic position, exercise-related activity schedules, pre- and post-exercise manoeuvres as experimental protocol differed for each company. A complete analysis of the survey is presented elsewhere (10).

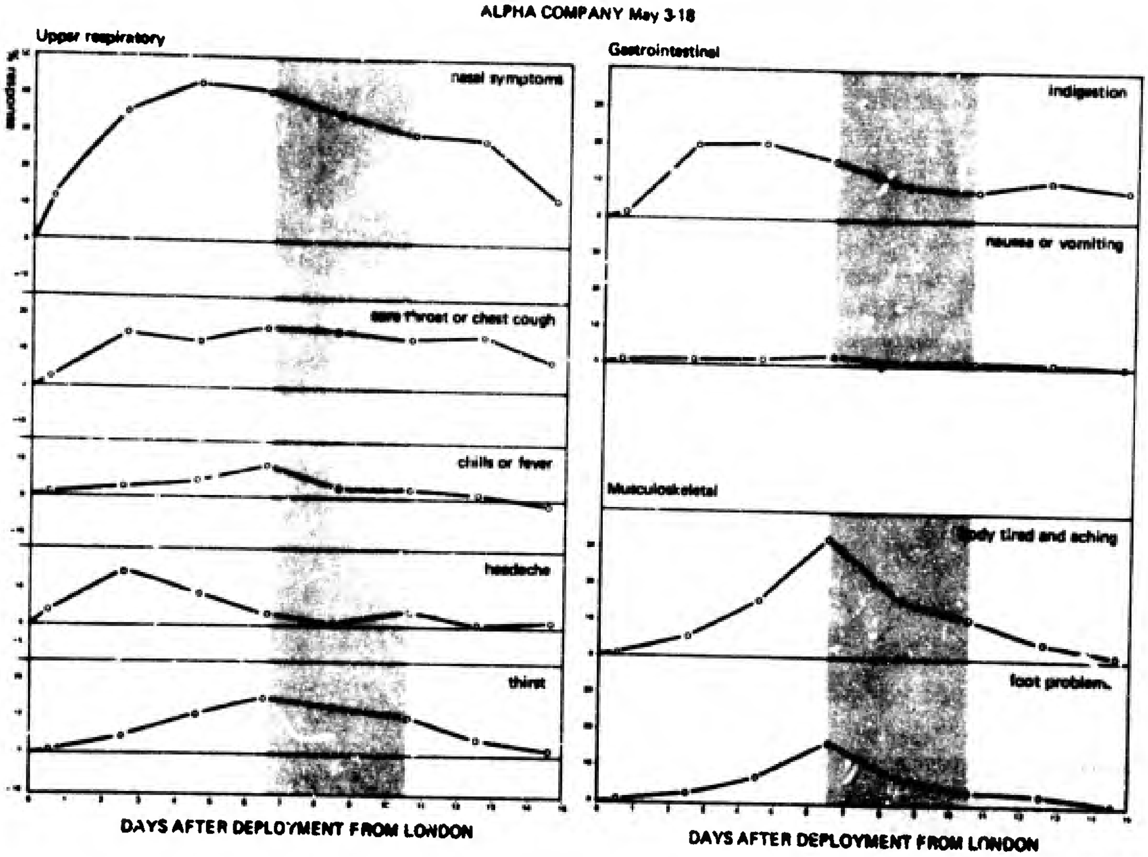

Figure 2. *The frequency response (% difference from pre-exercise incidence) of individual symptoms recorded by Alpha Company. The shaded area corresponds to the main exercise period (Southern Advance). The interval immediately BEFORE the shaded area corresponds to the period of Eskimo Point activity. The entire interval immediately AFTER the shaded area corresponds to the period of the Churchill Concentration area.*

A. *Incidence of upper respiratory discomfort, headache and thirst.*

B. *Incidence of gastrointestinal discomfort.*

C. *Incidence of musculoskeletal discomfort.*

The outstanding feature of the survey was the relatively high incidence of nasal symptoms reported in all companies, unaccompanied by more systemic manifestations of upper respiratory discomfort. Where symptoms did progress to the development of colds, the incidence of colds ranged from 15% - 30% in the four companies. A more extensive analysis of colds is discussed in the section dealing with Vitamin C.

With respect to gastrointestinal discomfort, there was a relatively low incidence of indigestion, heartburn or constipation. Considering that the troops were living on "hard" rations during the exercise and in the light of anecdotal reports of a high incidence of gastrointestinal complaints on previous Northern exercises, this finding was unexpected. It is now believed that the relatively mild climatic conditions contributed to the low incidence.

Experience gained on Exercise Northern Ramble demonstrated that epidemiologic surveys based on questionnaires and daily symptom cards are feasible, informative, simple, convenient, and offer the advantage of lending themselves to computer programming. The latter is currently under development. DCIEM intends to continue this program in order that health profiles under a variety of environmental conditions may be obtained. The predictive value of such data should prove useful in the planning and formulation of medical and dietary requirements for maintenance of optimal health under conditions of stress.

VITAMIN C: Effect on Upper Respiratory Distress and General Well-being

Increased cold tolerance and reduction in the frequency and severity of "colds" are two beneficial effects often attributed to Vitamin C. Perhaps the most controversial attribute is that pertaining to the relief of upper respiratory symptoms. Indeed, Pauling (11) has estimated that "the regular ingestion of 1000 mg (of Vitamin C) leads to a decreased incidence of colds by about 45% . . . (and) . . . to a decrease in total illness by about 60%". While this estimate was based upon results obtained over a one-week period at a Swiss ski school (12) a more recent study (13) which surveyed a metropolitan civilian population over a three-month period was unable to demonstrate a substantial reduction in either the frequency or duration of colds. This study did show however, that subjects taking 1000 mg of Vitamin C per day experienced less severe total disability associated with constitutional symptoms such as malaise, chills and fever and the number of days confined to the house. Previously, LeBlanc *et al* (14) reported that the daily ingestion of 525 mg ascorbic acid increased resistance to low environmental temperatures. This beneficial effect was particularly evident with respect to the peripheral circulation where the vitamin group showed consistently higher skin temperatures in the face of similar deep-body temperatures. This pattern was reflected in the incidence and severity of foot problems reported by the subjects emerging from a cold chamber after a stay of some 13 days. Vitamin C reduced significantly the duration and severity of muscle weakness and the number of swollen, painful feet. While Vitamin C may have an ameliorating effect on health problems and man's resistance to cold, evidence to the contrary does exist. Glickman *et al* (15) were unable to demonstrate any beneficial effect on cold tolerance of 200 mg/day Vitamin C and Tyrell (16) was unable to show that 3000 mg of Vitamin C daily had any influence on the frequency of colds.

In view of the uncertain role which Vitamin C may play in both cold tolerance and general health, it was decided to utilize the health survey protocol in an assessment of Vitamin C. Pursuit of this line of investigation was prompted by the realization that the RP-4 rations (since replaced by the IRP) provided a maximum of 37-41 mg Vitamin C per day in a single fruit drink mix. Previous observations suggested that the fruit drink mix was an unpopular item in the rations and was not consumed regularly. It was therefore possible that the intake of Vitamin C in the troops was well below recommended dietary allowances.

Subjects were drawn from one company of 112 men. Individuals were assigned by tent group to either the Vitamin C or placebo preparation, 50% of each tent being allocated randomly to each preparation. The tent group commander was provided with two bottles labelled with the names of the individuals who were to receive pills from that particular bottle. One bottle contained 500 mg tablets of Vitamin C; the other, a lactose placebo. The tent group commanders were instructed to issue each man with his respective pill, twice a day – once with the morning meal and once with the evening meal – and to ensure that each man consumed the pill. The dispensing of pills began with the evening meal of the first tenting day. At the conclusion of the exercise, pills were discontinued but daily symptoms continued to be recorded for four days after return to CFB London. During this four-day period, all personnel were required to complete a questionnaire pertaining to their Northern service. Those questions relating to general health surveyed such things as smoking habits, how many colds each year did a man usually have; at what time of year did he usually have a cold; did he have a cold on the present exercise and if so, was the cold mild or severe?

Collation of the data involved assessment of the frequencies of all symptoms recorded daily throughout the company, tent groups, and treatment groups. For purposes of this study, a fairly restrictive definition of a "cold" was arrived at. A cold was judged to be present if any two nasal symptoms occurred in conjunction with a minimum of sore throat or chest cough persisting for two or more days and having been absent at the time the nasal symptoms began. Frequently, headache, chills or fever and thirst were indicated at some time during the symptom constellation. Once an individual was judged to have had a cold, his Personal History Questionnaire was checked to see if he had indicated the presence of a cold during the exercise. In those cases where the absence of a cold was indicated, the symptom constellation was checked again. Those cases, in which only one of either sore throat or chest cough was indicated in the absence of more constitutional symptoms, were then judged as not having experienced a cold. In the majority of cases, the daily symptom card extrapolation correlated positively with the Personal History Questionnaire. The data presented in Table 2 indicate that the random allocation of individuals to treatment groups produced two homogeneous populations with respect to age and incidence of the usual Spring cold.

TABLE 2

The Mean Age and Common Cold History of Individuals Allocated Randomly to Vitamin C and Placebo Preparations

Group	N	Age	Incidence of Usual Spring Cold %
Vitamin C	56	25.3 ± 6.3* (Range 17 – 40)	61.6
Placebo	56	25.4 ± 8.1 (Range 17 – 47)	60.0

*Mean ± S.D.

Figure 3 depicts the frequency response (percent difference from pre-exercise values) of symptoms throughout the exercise. It is apparent that Vitamin C had a marked effect on the development of nasal symptoms throughout the Company. Where such symptoms progressed to the development of a cold, Vitamin C appeared to have an ameliorating effect (Table 3).

Of the 14 tent groups involved in this study, nine groups (64.3%) indicated the presence of at least one cold during the exercise period. Of these nine tent groups, six (66.6%) indicated colds present only in placebo individuals, while the remaining three (33.3%) indicated colds present in both placebo and Vitamin C individuals. In no case did a tent group indicate the presence of colds in Vitamin C individuals only. The data in Table 4 show that while the incidence of colds was influenced by Vitamin C, the duration of cold symptoms as related to the presence of nasal, throat, or chest complaints was not significantly influenced.

With respect to generalized constitutional symptoms related to the feeling of well-being (headache, chills or fever, body tired and aching), the total duration of these symptoms in those individuals reporting colds was significantly less in the Vitamin C Group (Table 5).

In summary, it appears that the daily ingestion of 1000 mg Vitamin C significantly reduced the incidence of colds and the duration of constitutional symptoms related to the feeling of well-being of the individual. The efficacy of Vitamin C may simply be related to the fact that the required dietary intake of Vitamin C was not realized in those troops eating RP-4 rations and not receiving the Vitamin supplement. Evaluation of the ascorbic acid status of individuals during Northern exercises is presently being undertaken.

DEHYDRATION

Experience gained from the various serials of Exercise New Viking indicates that dehydration appears to be the main contributing cause of casualties and loss of effectiveness. Indeed, unpublished reports suggest that if a serial has a clearly evident dehydration problem (after 4-6 days on the trail) then the casualties for other reasons are correspondingly high. Dehydration arises because of:

a) the relative unavailability of potable water

b) increased loss of body water through sweating

c) increased respiratory loss of water

d) cold-induced diuresis.

The relative unavailability of potable water is undoubtedly the main contributing factor to dehydration. It is interesting to note that while the recommended daily intake of fluid is 3-4 quarts, the RP-4 ration provides only 1 qt 18 oz to a maximum of 2 qts 4 oz (1966-1972 issues) in the form of fluid mixes. It is clear that if all the fluid mixes were consumed (many are not because of personal dislike) then each individual would still have to supplement his fluid intake with from 28 oz to 1 qt 14 oz of water to ensure the recommended intake. The only source of water is melted snow and while its preparation is time-consuming and the yield per unit of snow is small, experience has shown that care in its preparation and consumption pays dividends in terms of preserving troop effectiveness.

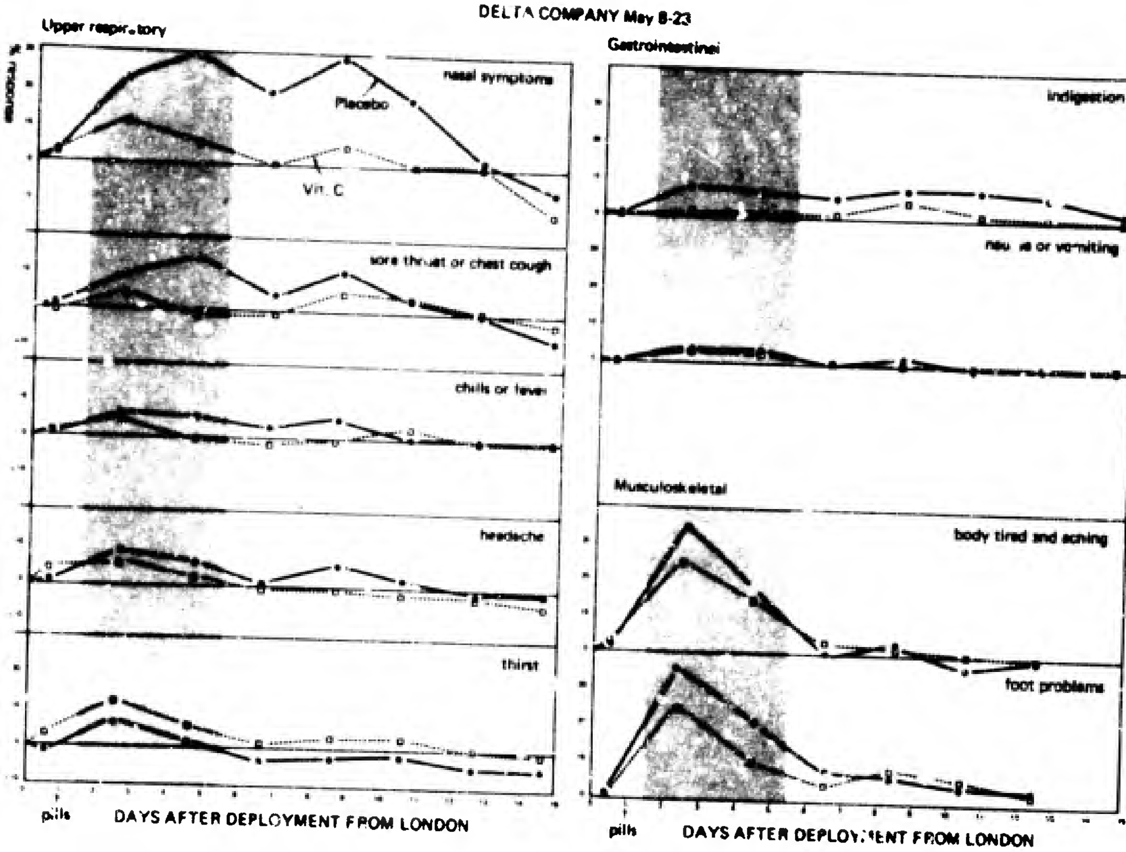

Figure 3. The frequency response (% difference from pre-exercise incidents) of individual symptoms recorded by Delta Company. The shaded area corresponds to the main exercise period (Southern Advance). The interval immediately AFTER the shaded area corresponds to the period of the Churchill Concentration area. The interval Day 13-15 corresponds to the post-exercise period at CFB London

□ - - - - □ *Vitamin C supplement*

● —— ● *Lactose placebo*

A. *Incidence of upper respiratory discomfort, headache and thirst.*

B. *Incidence of gastrointestinal discomfort.*

C. *Incidence of musculoskeletal discomfort.*

TABLE 3

The Incidence of Common Colds Reported by Individuals Receiving 1000 mg Daily Vitamin C or a Lactose Placebo

Group	N	Frequency	Percent Frequency
Vitamin C	56	6	10.7
Placebo	56	14	25.0
χ^2	3.87	$P = 0.05$	

TABLE 4

The Mean Duration of Upper Respiratory Symptoms Reported by Individuals Afflicted with a Common Cold while on Vitamin C or a Lactose Placebo

Group	N	Duration of Symptoms (days)	
		Nasal	Throat/Chest
Vitamin C	6	4.2 ± 3.8*	4.3 ± 3.0
Placebo	14	5.6 ± 2.8	6.0 ± 3.0
P		$>0.4 <0.5$	$>0.2 <0.3$

*Mean ± S.D.

TABLE 5

The Mean Duration of Constitutional Symptoms Related to a Feeling of Well-Being Reported by Individuals Afflicted with a Common Cold while on Vitamin C or a Lactose Placebo

Group	N	Duration of Symptoms (days)
Vitamin C	6	0.8 ± 0.8*
Placebo	14	2.4 ± 2.1
		$P < 0.05$

*Mean ± S.D.

During the past year, DCIEM has been involved in a program to assess the extent of dehydration and examine ways and means of reducing body water loss. Initial experiments were conducted on troops of a New Viking serial in March 1972 (17). During the exercise, temperatures ranged from -40°F (windchill 1900 kg cal/m^2/hr) to +29°F on one warm day. The average night temperature was -15°F while during the day it rose to +5°F. Body weights were determined before and after the exercise and the efficacy of a sodium chloride supplement on reducing body weight loss was examined. Sodium chloride was selected because of the reported sodium chloride dumping which accompanies the diuresis induced by cold-exposure (18). It was felt that such dumping might have an effect on osmoregulation such that thirst stimulation would be reduced. Supplementation with sodium chloride might be expected to conserve the osmoregulatory thirst-stimulating mechanism with the result that the individual would be motivated to drink more fluid. Accordingly, sodium chloride (650 mg) or sodium bicarbonate (325 mg) tablets were administered to all troops throughout the exercise. The pills were dispensed twice daily by tent group, 50% of each tent having been allocated randomly to one or the other preparation. Body weights were determined prior to the exercise and on three different occasions during the exercise. The serial required the men to be resident in the Churchill area for one week of initial training during which time a 3 kilometer and 16 kilometer march took place. Following these marches, a body weight loss of approximately 1% occurred (Figure 4). The sodium chloride group lost slightly less weight then did the sodium bicarbonate group. During the 24 hours immediately following the first phase of the serial, this weight loss was completely regained, the sodium chloride group gaining slightly more weight than the bicarbonate group. The rapid replenishment of weight loss indicated that it was likely due to loss of water and not body tissue.

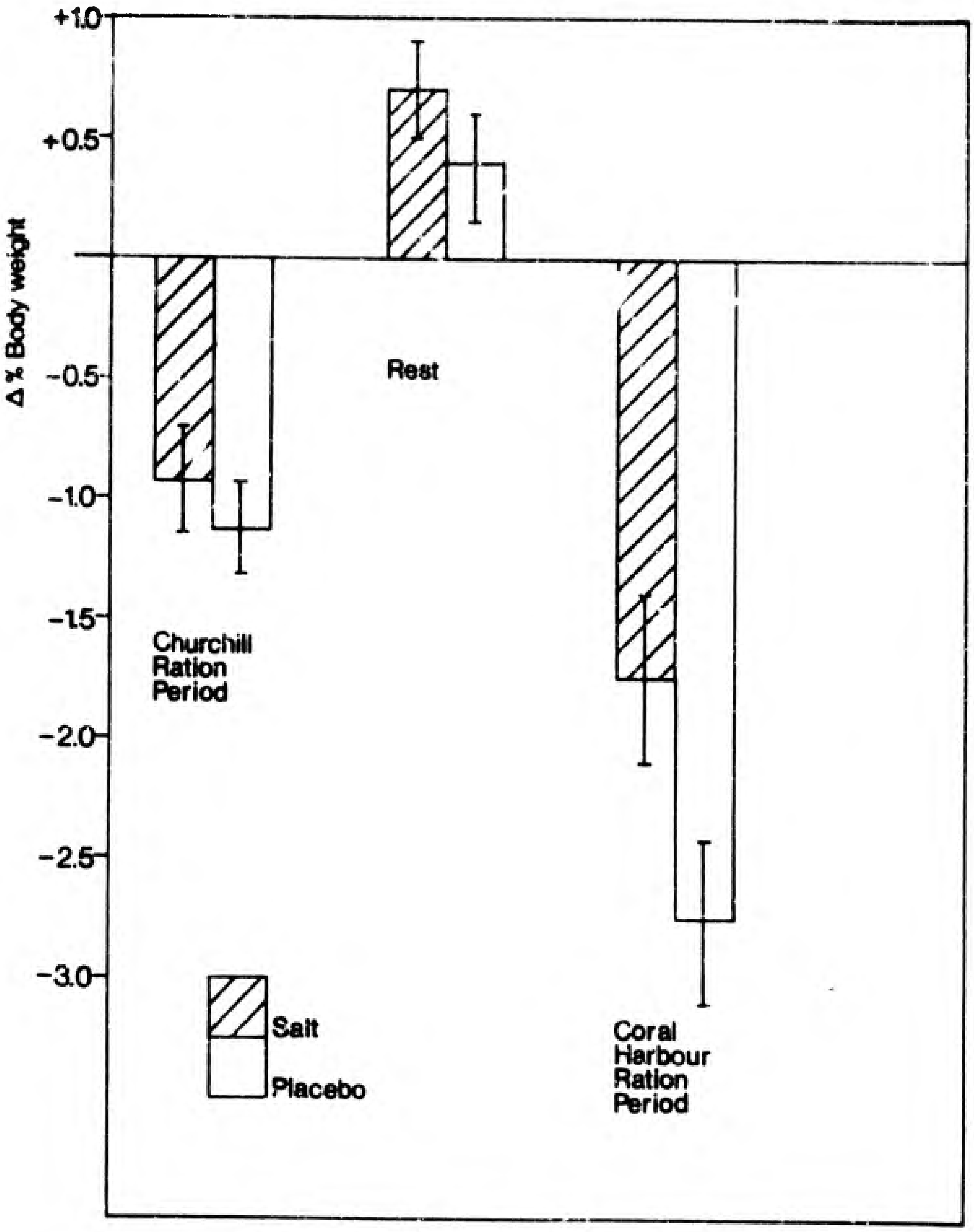

Figure 4. Alterations in body weight during Exercise New Viking expressed as % of the pre-exercise values. The vertical bars indicate the standard error.

The second phase of the serial required the troops to be airlifted to Coral Harbour, N.W.T., and live in the field for five days. During this time, the sodium chloride supplemented group lost approximately 1.5% body weight while the sodium bicarbonate supplemented individuals lost approximately 3% body weight. Unpublished reports suggest that the 3% weight loss which occurred over the five day period could have resulted in a loss of efficiency of 25% -- 30%. Dehydration obviously can make an appreciable contribution to loss of troop effectiveness in the North.

The dehydration supplementation program was subsequently extended to Exercise Northern Ramble during which body-weight data were recorded on members of all three field companies before and after the exercise. Hematocrit data were recorded on members of one company selected for sodium chloride and lactose placebo supplementation. In addition, precise body water determinations before and after the exercise period were carried out by an isotope dilution technique using deuterium oxide. As the results have been presented in detail elsewhere (10) and as virtually no evidence of dehydration was found, the data are omitted from this report.

It is perhaps not surprising that no evidence of dehydration was found on this exercise in view of the relatively mild environmental conditions and low level of metabolic activity experienced. Potable water was readily available during the period of the study and deuterium oxide data confirmed that total body water was not altered under the prevailing conditions. Body weight and hematocrit data remained essentially constant. Sodium chloride supplementation had no demonstrable effect on any of the three parameters measured. It would therefore appear that dehydration is not likely to be a serious problem under relatively warm Spring subarctic conditions. Nevertheless, it remains a problem worthy of further investigation under more strenuous climatic and metabolic conditions and work is proceeding in this direction.

COLD INJURY

Cold Induced Vasodilation Reactions

Although the total incidence of casualties is rather low numerically, frostbite injuries continue to occur on Canadian Northern exercises. One of the concerns of DCIEM is the prevention of such injury for, as mentioned previously, the loss of one man in an operational situation can impede the effectiveness of the group to which that individual belongs. It would be desirable to preselect individuals for Northern service in such a way that the risk of cold-injury is significantly reduced. One of the mechanisms postulated in the pathogenesis of frostbite is the vasomotor mechanism cooling of the periphery leads to peripheral vasoconstriction and a reduced capillary blood flow. This in turn leads to sludging in the capillaries, thrombosis formation, tissue hypoxia and eventual cell necrosis and death. The cold-induced vasodilation (CIVD) reaction is a meaningful parameter of the response of the circulation to cold and has been exploited by Yoshimura and Iida (19) in assessing the susceptibility of individuals to frostbite. DCIEM has an ongoing program whereby individuals going on Northern exercises are tested for their CIVD reactivity. To date one study has been completed on one serial of Exercise New Viking (17) and is currently being carried out on a second exercise. In the completed study, CIVD reactivity was determined pre- and post-exercise and some representative data are shown in Figure 5. The results observed present something of a paradox in

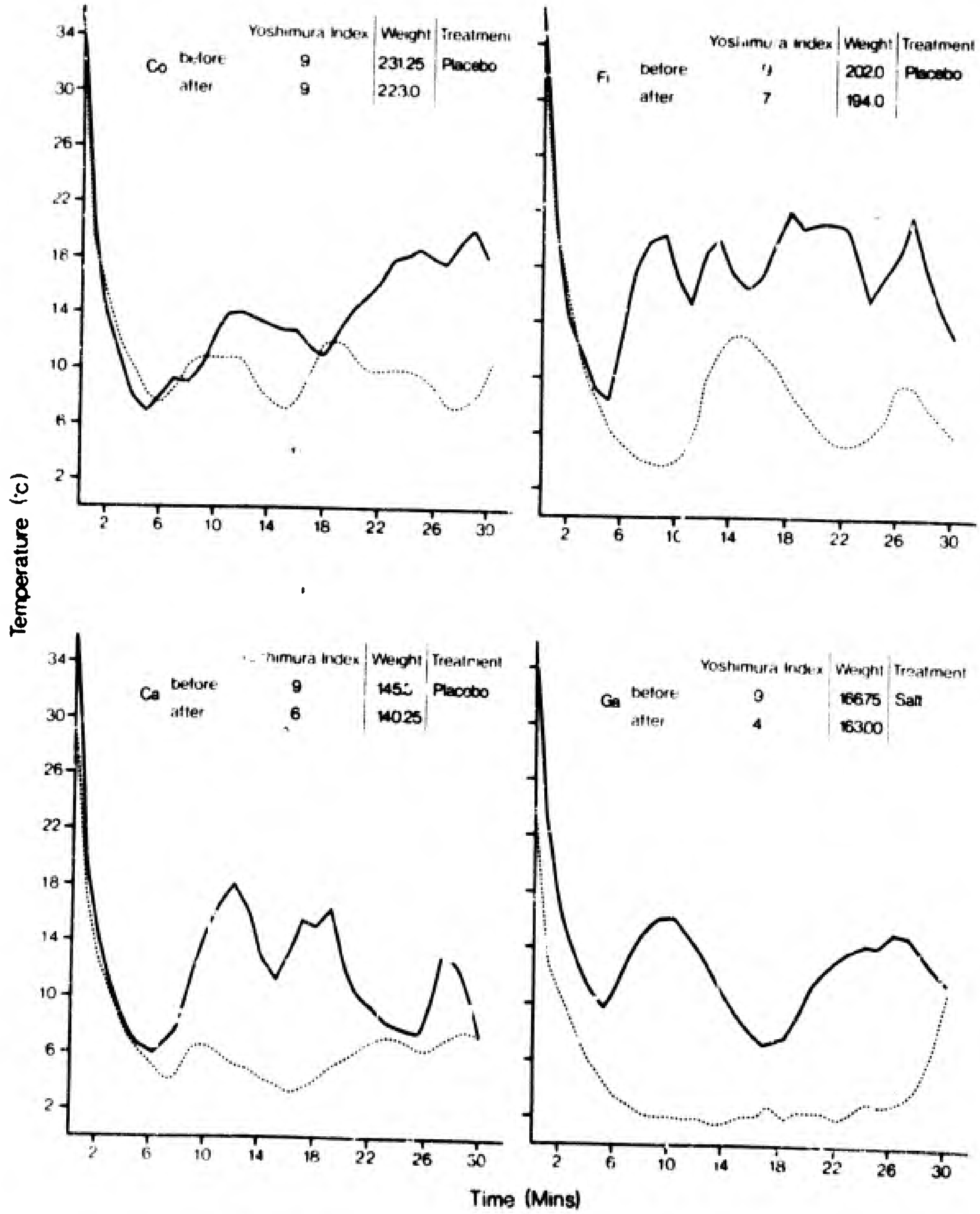

Figure 5. *Cold-induced vasodilation reaction of four subjects before and after Exercise New Viking. The lines show the skin temperature response of the left middle finger to immersion in ice water. The solid line depicts the pre-exercise response. Computed Yoshimura values, body weight changes and type of pill taken are shown. On a scale of 3 to 9, a Yoshimura value of 3 indicates maximum susceptibility to frostbite.*

that the majority of the individuals tested demonstrated a reduced CIVD reactivity after the exercise. One would expect normally that some degree of adaptation in terms of an enhanced reactivity would have been observed following a period of cold-exposure. It would indeed be premature to draw any firm conclusions from these data but the implications of the results, if confirmed, could be significant in terms of frostbite susceptibility during initial phases of Northern exercises. Similar results have been observed by LeBlanc (20) with respect to the cold pressor test and may indicate that there is an increased sympathetic tone with short-term cold-exposure.

Because of our continuing interest in Vitamin C and in view of the higher skin temperatures reported in cold-exposed subjects taking Vitamin C (14), a preliminary experiment examining the effect of ascorbic acid (2000 mg/day for one month) on CIVD reactivity has been carried out. The sample size is limited (n = 6) but indications are that CIVD reactivity is enhanced by Vitamin C supplementation. It appears possible that a relative deficiency in Vitamin C (discussed earlier) could be responsible for the reduced reactivity observed on Exercise New Viking.

CALORIC REQUIREMENTS AND ENERGY EXPENDITURE

The Canadian Armed Forces have a stated requirement for a light-weight food ration of minimum caloric content sufficient to sustain an individual, without physiological damage, for up to 10 days on foot in all climates. Other Commonwealth countries have accepted 1900 calories daily as the minimum caloric intake which satisfies this requirement for temperate and Arctic climates. For Northern environments, the requirement is increased to 3000 calories daily because of increased energy expenditure. Whereas the United States Army Long Range Patrol (LRP) ration (1000 calories/unit) satisfies most operational requirements, it apparently does not meet the subjective demands of the Canadian soldier. To meet these demands on the basis of bulk appetite satisfaction alone (not taking into account the acceptability of individual ration components) it is estimated that four LRP rations (total of 4000 calories) would have to be consumed each day. This would require that the individual carry 28 lbs of food over a 10-day period as opposed to 21 lbs for a consumption of 3000 calories daily. Because the individual soldier needs as great a capacity as possible for carrying essential operational equipment, any increase in weight of food becomes undesirable. The present LRP ration is very close to the theoretical minimum weight of a balanced diet and hence very little improvement in terms of unit weight can be expected. It would therefore appear that if the caloric intake were restricted to the absolute minimum (3000 calories/day) to maintain efficiency without physiological impairment, the soldiers' appetite would not be satisfied. Complicating the situation is the fact that a number of items in the LRP ration are unacceptable to the Canadian soldier and would tend not to be consumed. These factors would tend to jeopardize an individual's sense of well-being and could therefore lead to a decrease in his level of effectiveness.

Accordingly, a review of the Canadian Forces LRP requirements has been undertaken recently by the Directorate of Clothing and General Engineering (DCGE) and DCIEM. Factors under study are:

a) Energy expenditure during moderate and heavy military activity in temperate and Arctic climates.

b) The minimum caloric intake necessary to maintain adequate Canadian military efficiency in the above situations.

c) The maximum period over which it is physiologically safe to maintain the Canadian soldier on such restricted intakes.

d) The frequency with which such periods can be safely repeated.

An attempt to assess energy expenditure under Arctic conditions was initiated on Exercise Northern Ramble. As in the previous studies conducted on this exercise, a single company of the 1 RCR was tested. Assessment of energy expenditure in the field was based upon the functional relationship between heart rate and work load, heart rates being monitored during representative tasks by a cassette recorder carried by the man. Prior to deployment for the exercise area, the heart-rate response to a graded work load of all personnel was determined and this was repeated upon return to CFB London. These data were used to estimate the aerobic work capacity before and after the exercise. The data obtained during the exercise were compared with the ergometric data to establish the relative severity of the exercise activity.

The heart rate method of assessing activity levels relies on the linear relationship between heart rate and oxygen uptake which exists up to about 70% of the maximal oxygen uptake. Such a relationship is only found to be reliable between heart rates of 100 to 180 bpm. Above and below these values the validity of heart rate as an indicator of metabolic demand is questionable. Although respirometry is definitely the method of choice for determining energy expenditure at all levels, it was not feasible under the conditions of this exercise.

As most troop movements on Exercise Northern Ramble were made by armored personnel carrier or helicopter, foot movement was minimal, being restricted to a single 10-kilometer march in the company under study. This took place through snow-covered wooded terrain and small areas of dry, loose sand. Each individual was dressed in Arctic gear and carried a weapon, snowshoes and rucksack weighing 40-50 lbs. Progress was approximately 2000 metres per hour. Under these conditions, the work load approximated 600 kilogram metres which was equivalent to an oxygen consumption of 7 k cal/min. Extrapolation of the heart rate data to the theoretical maximum of 190 bpm for healthy young males indicates that the work load represented approximately 50% of the aerobic work capacity. Since this activity level occurred only once during the exercise, it is apparent from the above description that energy expenditure was not high. This conclusion was supported by the absence of any training effect on the post-exercise ergometer tests.

Work is currently in progress on winter serials of the New Viking exercises and heart-rate data are being supplemented by respirometry in order that more valid estimates of energy expenditure may be made.

SUMMARY

Some Canadian Military operations dictate rapid deployment of mobile land elements from a temperate to a Northern environment and the subsequent deployment of small bodies of troops on operational patrols. Under these conditions, it is paramount to the successful accomplishment of the mission, that the individual be protected maximally against environmental hazards and that his health and well-being be maintained.

DCIEM is involved in defining the nature, incidence and severity of health problems related to such operations and with investigating problems of dehydration, cold injury and metabolic demands. Though more extensive epidemiologic data are required to better define biometeorological effects relating to health and disease, it is clear from the survey conducted to date that symptoms related to the well-being of the individual are influenced by movement from a temperate to a cold environment. Of particular interest are those symptoms relating to upper respiratory distress and the apparent ameliorating effect of Vitamin C on their development and progression.

Dehydration continues to be a problem in the North but it is probable that its severity is related to the severity of existing environmental conditions. During Spring operations where potable water is usually available, dehydration is unlikely to appear. When it does occur (under conditions of more severe cold), salt supplementation may be beneficial. Further work is required to substantiate this observation.

The threat of cold injury is present constantly in the North and, while thorough training and adequate clothing are perhaps the two most important preventative counter measures, physiological and dietary approaches to the problem may extend protection even further.

Energy expenditure and caloric requirements under conditions of Northern military operations justify high priority investigation in view of the Canadian Military's requirement for lightweight, minimum caloric rations.

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