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Nutritional and psycho-physiological assessment of members of the XVI Antarctica expedition

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Abstract

The present studies are aimed to evaluate the effects of physiological stress and metabolic requirements necessary to maintain homeostasis and physical and mental functions during stay at Antarctica in expedition members. Nutritional and psycho-physiological assement of the members of the XVI Indian Scientific Expedition to Antarctica was carried alongwith supplementation of vitamins, viz., vitamins, viz., vitamin C and vitamin E to reduce the oxidative stress.

Thrity two members of the XVI Inidan Scientific Expendition to Antarctica were taken for the study. Initially, all the members were briefed about the scope of the project and their informal consent obtained. After this, initial paramenters like age, height, weight, etc alongwith body composition which included body fat, lean body mass, amount of water in terms of percent and volume, BMR and hematological parameters including platelet aggregation were recorded. On the basis of age, height and weight, the subjects were divided into four groups as recorded. On the basis of age, height and weight, the subjects were divided into four groups as control (no supplementation with vitamins), experimental groups (supplemented with vitamin C, vitamin E and vitamin C and vitamins). After 15 days all the above mentioned parameters were measured regularly except platelet aggregation which was done only after an interval of one month and just before leaving Antarctic station Maitri.

For most of the time, the expeditioners enjoyed a comfortable free-living environment with only brief exposures to the outside elements, except for two expeditioners remained in a tent outside the main station for 35 days another batch of three expeditioners who stayed outside for twenty days. They were exposed to the typical Antarctic environment. The station area was maintained at 19-22 ° C whereas the outside temperature was between -8°C to +8°C station also has sports facilities, library and enter tainment room where the expeditioners relax, play indoor games such as cards, chess, and table-tennis, and watch video films and listen music.

The ration for expeditioners consisted of canned and fresh (for some time) fruit, fruit juices, freshly cultured yoghurt, frozen meat, firsh and poultary items. Perishable fresh fruit and vegetables were available for a limited period, although

fruit and vegetables suitable for cold storage were available for longer period. A good vareity of frozen, canned and pulses were also available. In fact, if the expeditioner did not like the food made for the whole of the group, he was free to make food of his choice.

BODY WEIGHT increased throughout in all groups but in the ;control group the gain was maximum. It increased from initial weight of 58.6+ 5.6 kg to the final weight of 63.0+7.5 kg taken just before starting return journey. Gain in others was also noted but the gain in body weight was less as compared to that control group. The gain in body weight was minimal in the group the received C and vitamin E.

Per cent BODY FAT continuously increased from initial value of 20.9% to final value of 23.9% at the end of study period in the control group. Similar was the trend in the group that received vitamin E alone. But those who took vitamin C and a combination of vitamin C and vitamin E showed less increase in their body fat as conpared to those who were without any vitamin supplementation.

HEMATOLOGICAL parameters-hemoglobin, platelets, WBC, RBC, packed cell volume, etc. were measured in all the four groups initially and after 15 days (on reaching Antarctica) and after 30 days. Hemoglobin increased from the initial in Hb was less in the other groups supplemented with vitamin C and a combination of vitamin C and vitamin E. But the change in Hb was very much less in those who received vitamin E alone. Similar trends has been observed with packed cell volume, platelet counts also.

In addition to these, lipid profile - cholesterol, high-density-lipoprotein cholesterol, triglycerides, protein, gamma-gultamyl transferase, cholinesterase, uric acid have been estimated. The data showed that the changes observed in lipid profile in non-supplemented group were different from those received vitamin C and vitamin E indicating beneficial effects.

In conclusion, it may be stated that supplementation with vitamin C and vitamin E will have the potential to produce beneficial changes in the body weight, per cent body fat, hemoglobin, lipoprotein lipid profile. However the gain in body weight may be due to decreased energy expenditure because of the sedentary life rather than due to physiological changes as a result of low temperature. Moreover, the facilities provided for living in the Antarctica have largely removed the need for cold acclimatization as the station is well maintained at comfortable temperature and expeditioners remained mostly inside the station except for short duration when they go out on the assigned work.

Introduction

The great number of environmental factors that cambine to influence - physical and mental health of which nutrition is petinent. Food contributes to the building blocks of the body through energy, vitamins and minerals. Nutrition has always played an important role in the history of mankind. Paucity of food,

resulting in starvation and deficiency diseases, were and still are powerful contribute to infulence the history of mankind. Moreover, alongwith the increasing. Further, overnutrition can also be a problem and is nt a new thing. An excess intake of calories, as well as of particular nutrients, such as fat, cholesterol and sugar, alongwith inactivity are responsible for the prevalence and accumulation of metabolic derangements that express themselves in cardiovascular risk indicators shaping our current morbidity and mortality data.

In the history of Antarctic exploration, the scourges of scurvy and semi starvation have played an important part in the success or failure of expeditions as have the hazards of exposure and accident. Studies have been made on the mechanisms that might be involved in man's physiological responses to polar conditions (Lewis and Masterton, 1963). Majority of these have included routine measurements of body weight, skinfold thickness and energy balance, which have helped in evaluating the nutritional requirements of men working in polar regions.

The Antarctic continent has adverse environmental conditions such as high uv radiation, magnetic field, high wind velocity and extreme cold conditions. These environmental conditions either alone or in combination cause many adverse effects. Exposure to extreme cold also poses problems of frostbite. These madladies at Antarctic region are often attributed to disturbances in microcirculation and capillary permeability. All these changes might be due to the oxidant stress which is enhanced by the stressors at the Antarctic region. The body's susceptibility to free radical stress and the related damage is governed by the overall balance between the stress level and the antioxidant potential of the human body.

Platelets constitute once of the four main components of the hemostatic system, which protects the body from the effects of trauma and preserves the integrity of blood vessels. Platelets represent a first-line defence in this system which also includes the vessel wall, the coagulation and fibrinolytic systems. Upon activation, platelets become very sticky, adhere to a variety of sufaces and to each other, and their membrane allowa rapid activation of certain coagulation facotrs. The stimuli that activate platelets are manifold. The coagulation process involves a complex series of reactions that eventually changes the plasma fibrinogen to fibrin, which links and reinforces the platelet plug that is formed when platelets are rendered sticky. Platelets may also have a direct role in the devleopment of arteriosclerotic changes of blood vessels as platelets have receptor sites for low-density lipoproteins, involved in the development of arteriosclerotic state. Thus, platelets occupy a central role in hemostasis, whether it occurs under physiological or pathological circumstances.

Vitamin E may brek the chain reactions started by the reactive radicals of endogenous or exogenous origin (e.g., produced as byproducts of normal metabolishm after infections or by radiation), and protecting cells from lipid

peroxidation (Ames 1983). According to certain hypothesis, vitamin E traps secondarily propagated radicals from the chain reaction of polyunsaturated fatty acids peroxidation and exogenous radicals caused by environmental agents (Grey 1986).

When sedentary life style is combined with unrestricted access to food rich in fat, weight stability for mahy presons tends to become established only once the adipose tissue mass has become excessively enlarged (Flatt 1988; Astru et al. 1994). As the body protein content and glycogen reserves are usually appropriate to sustain habitual functions and activities, the most perceivable, and important aspect of body weight regulation is the amount of body fat present when the steady state of weight maintenance becomes established.

Men living in Antarctica suffer considerable emotional strain as a result of physical isolation and social deprivation, in addition to the physiological stress imposed by exposure to cold, solar radiation, magnetic field, etc. Friedman et al. (1958) have demonstrated that emotional stress is accompanied by an increase in serum cholesterol and reduced blood clotting time. Exposure to cold has also been shown to raise the serum cholesterol level (Peterson et al. 1960). Furthermore, an increased craving for dietary fat in extreme cold climate has been reported (Frazier 1945; Buston 1950). It might therefore be expected that men living in Antarctica exposed to both cold and emotional stress and allowed a free choice of diet would show some increase in their serum cholesterol levels and some reduction in their blood clotting time.

Being a very important source of energy, lipids serve a variety of other needs. They are improtant for the patency of structure and function of biological Membrances. Of serveral hormones. They help to regulate the uptake and excretion of nutrients by the cells. Lipids are found in almost every natural food. Fruits and vegetables have small amounts of lipids while meat, milk, and table spreads have large amounts. Cholesterol, cholesterol esters, free fatty acids, and phospholipids are also present in the food that human consume.

Among the multitude of factors known to prevent or promote weight gain, some are inherited and others are related to life-style, socioeconomic and dietary conditions (Boucchard et al. 1993). Given the complexity of the interactions among these factors, it is imprerative to realise that the problems of weight maintenance depend on (a) what are the phenomena that operate to maintain body composition and energy balance once a particular weight maintenance plateau has been reached and (b) what are the factors influencing the size of the adipose tissue mass for which weight maintenance tends to become established in a given individual under a particular set of circumstances.

The principle aim of the present study under taken in Antarctica during the XVI Indian Scientific Expedition to Antarctica was to determine the magnitude and pattern of body weight changes and possible mechanism and the role of antioxidants-vitamin C and vitamin E on these changes. Besides, the free life

style and abundant food, its effects were evaluated by measuring platelet aggregation and plasma lipid profile at monthly intervals on a groups of men serving at the Indian station "Maitri" during December 1996 and February 1997, i.e., on summer group.

Material and methods

It was not practical to determine the subjects' base line data before starting the trip to the Antarctica, became the members of the expedition were scattered in different parts of the country. So base line data were taken on boardship only after 4 days because the container in which the scientific equipment's were kept was onened and the lab was set up in the medical cabin of the ship - Polar Bird. Further, an attempt to determine an accurate weight up to lOg with an electronic balance on the often furiously rolling ship had beenunsuccessful. Other equipment's like platelets aggregometer, blood cell analyser, ststmex F820 model, did not give any trouble.

Thirty two members of the XVI Indian Scientific Expedition to Antarcitca were taken for the study. Initially, all the members were briefed about the scope of the project. After thgis, initial parameters like age, height, weight, amount of water in terms of percent and volume, BMR and hematological paramenters including platelet aggregation were taken. On the basis of age, heiht and weight, the subjects were divided into four groups as control (no supplementation with vitamins), experimental groups (supplemented with vitamin C, vitamin E, and vitamin C and vitamin E together) as shown in Table 1. After 12 days all the above mentioned parameters were measured regularly except platelet aggregation which was done only after an interval of one month and just before leaving Maitri station at Antarctica. The fourth blood sample could not be taken because during the rowing sea journey, the diluent solution for blood was spilled.

For most of the time, the expediton enjoyed a comfortable free living environment with only brief exposure to the outside elements, except two groups of expeditioners consisting of two and three members remained in a tent outside for twenty days, respectively. They were exposed to the typical Antarctica environment. The station areas were maintained at 19 - 22° C. The station also had sports facilities, library and entertainment room called lounge where the expeditioners relax, play indoor games such a cards, chess, and table-tennis, and which video films and listen music.

The station ration, both during the journey period and at the station, consisted of mixture of canned and fresh (for some time) fruit juices, freshly cultured youghurt, frozen meat, fish and poultry. Perishable fresh fruit and vegetables for a limited period, although fruit and vegetables suitable for cold storage were available somewhat longer. A good variety of frozen, canned and dehydrated vegetables were supplied. Onion, potato and pulses were also available. In fact, if the expedition did not like the food made for the whole of the group, he was at free to make his food of his choice. However, a few expeditions preferred desi ghee and butter.

The food at the ship and station was plenty with wide choice of items. It was liberally supplemented with fresh fruits and salads, butter milk, curd cream, milk, juices, jam etc. with supplementary ration of soft drinks, biscuits, coffee, chocolate, Kellogg's snakes and luxury items such as cashew, almonds, pista, cherry etc.

All the men were weighted at approximately 12 days intervals. They were weighed with minimum clothings at the beginning to the nearest 0.5 kg. In the morning. However due to objections, the subjects were weighed in trousers. These values were called their base level weight and formed a base-line for comparisons.

Thus in short, the subjects comprised thirty two men of the summer party of XVI Indian Scientific Expedition to Antarctica. They were aged between 23 and 55 years, weighed between 45 and 78 kg (Table 1) and all had been declared fit by the medical board for the Antarctic expedition. Body composition - body fat, body lean mass, body water, basal metabolic rate was measured by Body Fat, Body lean mass, body water, basal metabolic rate-was measured by Body Fat Analyser, Maltron BF-905 model which is based in the measurements of flow of electrical signals as they pass through fat, lean and water in the body. The hematological observations were made during the 2nd week (taken as base level readings) and thereafter one month inervals after an overnight fast. Blood was rapidly withdrawn with minimal suction from an anteccubital vein, using disposable syringes between 0730 and 1000 h Apart of the EDTA blook was analyzed for hematological parameters - hemoglobin, WBC, RBC, Hematocrit. Platelet by Semi-Auto Micro Cell Analyser, Sysmex F820 model. Another portion of the blood was centfiuged to separate the plasma and stored at -20° C for fruther analysis of lipid profile. Cholesterol, high lipoprotein cholestrerol, triglycerides, uric acid, *y* - glutamyl transferase, cholinesterase were measured in the plasma by standard methods. Almost all the members of the party spent some time daily in the field with the exception that the environment team spent maximum time, i.e., from 0900 to 1630 h daily in the during the period of study and two teams consisting of three and two members doing work related to geology had also spent maximum time in the field. But during outside studies the members were well protected for cold with appropriate clothing.

Results

Body weight: Continuous increase in the body weight in the control group from the initial weight of 58.6 + 5.6 Kg to the final weight of 63.0 + 7.5 kg taken just before starting back journey with a mean maximum gain in weight of 5.87 Kg was observed around 35 days of stay (Tables 2 and 3) Gain in others was also there but was less as compared to that of the control group. The maximum gain in weight in other groups was 2.13 Kg (in vitamin C supplemented group), 2.98 Kg (in vitamin E supplemented group) and 1.50 Kg (in vitamin C + vitamin E

supplemented group). The gain in body weight was minimal in the group that received vitamin C and vitamin E. The data shows that weight gain in the subjects with the vitamin supplementation of the diets was less as compared to that observed to that observed in the control group.

Body fat: There was continuous increase in body fat form initial value of 20.9 % to final value of 23.9 % at the end of study period in the control group with a maximum increase of 3.85 % observed on the 36th day (Table 3 and 4). Similar was the trend in the group that received vitamin E alone. But those who took vitamin C and a combination of vitamin C and vitamin E showed less increase in their body fat as compared to those who were not given supplementation. Incidently, the maximum incerase in body fast was 2.31% in vitamin C supplemented group, 1.55% in vitamin E supplemented group and 4.88% in the vitamin C and vitamin E supplemented group. In terms of total fat, the increase was 3.75 kg in control group, 1.58 kg in vitamin C supplemented group, 1.50 kg in vitamin E supplemented group and 2.59 kg in the group given vitamin C and vitamin E together, at the end of 36th day.

Lean body mass : One of the consequence of rapid weight gain is the gain in body protein or lean body mass. This is especially true when the individuals are physically inactive.Maintenance of lean body mass is an energy expensive process. Lean body mass is the most meabolically active tissue in the body with respect to energy demands, accounting for the majority of calories to support the basal enery requirement (i.e., 60 and 70% of daily energy requirements for adults). If weight gain consists of significant amount of significant amounts of body protein, then the normal person will have a higher basal energy requirement and a decreased energy efficiency in terms of the weight gained as fat.

One of the characteristics of free- living humans is the tendency to overcast during such initial days. This suggests that the food intake is increased to gain in wight. And a state of hyperphagia. The stage for hyperphagia i.e, increased food intake above the normal, is set once food is not restricted. Thus, this state is enduring because hyperphagia is of of fixed duration for an individual The origin of these type of signals is not known. No doubt their existence is well established as the food intake is an event regulated by the central nervous ststem.

Body mass index : Perhaps more popular now is the use of body mass index (BMI). This is a useful term in that is an index of the body weight (kg) divided by the height (m) squared (wt/ht2). BMI correlates with body fatness and with the risk of overweight related diseases. Overweight is defined as a BMI between 25 and 30 and obesity is a BMI over 30.

The mean BMI has been found to be between 20 and 24.5 amongst all the subjects (Tabel 9). The BMI continuously increased in the control and vitamin C and vitamin E groups whereas no consistent pattern was observed in the vitamin C and vitamin E groups.

However, BMI does not assess body composition per se. It only provides a basis for assessing the health risks associated or presumed to be associated with excess body fatness. While total body fat is an important risk factor for several degenerative diseases, the distribution of the stored fat may have an impact upon the progression of disease states.

Body water: There was slight decrease in the percentage of body water in all the groups except in the vitamin E supplemented group. But the maximum decrease was observed after 36 days (Tables 5 and 6). The vitamin E supplemented group showed decrease in the percentage of body water only after 60 days. Although, all the subjects were requested not to take alcohol for atleast 24h prior to the test, some of the results showed wide variations which could be due non-compliance to the request.

Basal metabolic rate : There was continuous decrease in BMR upto 36 days, then increase after 48 days and again decreased in the control group (Table 10). BMR continuously increased upto 36 days in the vitamin E supplemented group. Thereafter, it decreased to the original level. However, BMR remained unchanged during the period of study in the vitamin C and vitamin E supplemented group.

Hematolgical indices : The changes in the blood hemoglobin concentration in the four groups are shown in Table 11. There was increase in hemoglobin concentration in all the groups except in those subjects who were taking vitamin E. The vitamin E supplemented group showed no change in the hemoglobin levels during the period of the study. Vitamin C supplemented group showed and increase in hemoglobin concentration. The subjects which were given both vitamin C and Vitamin E aslo showed practically no change in hemoglobin concentration.

The percentage of hematocrit in the four groups of subjects, control as well as vitamin C and vitamin E supplemented is shown in Table 11. There was an increase in hematocrit in all the groups except vitamin E supplemented group. With the increase in RBCs, the increase in hematocrit is expected. The vitamin E supplemented subjects did not show any change in hematocrit and RBCs.

Platelet counts in the four groups of subjects are shown in the Table 11. There was an increase in the platelet counts in all the groups after staying ast the Maitri Station for fifteen days. The counts decreased in all the groups but the decrease was less in vitamin C and vitamin C and vitamin E together supplemented subjects.,

Biochemeical indices : Total cholesterol, HDL-cholesterol and triglycerides in the four groups of subjects are given in Tables 12-14. Total cholesterol increased in the vitamin C supplemented group after 15 days at amitri station where triglycerides level decreased (Table 12). The cholesterol levels decreased after 60 days whereas triglycerides levies also decreased (Table 14). Gamma-glutamyl transferase levies increased in all the subjects except in the subjects which re-

ceived vitamin C (Table 15). Also the increase was less in the vitamin E supplemented subjects as compared to other subjects.

Cholinesterase activity in plasma remained practically unaltered in all the groups except those subjects which did not receive any treatment (Table 16). In fact, the activity of cholinesterase decreased. Uric acid concentration pattern was similar to the cholinesterase activity, that is, the concentration of uric acid decreased continuously in the control subjects whereas the levels of uric acid remained parzctically constant in vitamin supplemented group (Table 17).

Discussion

Body weight continuously increased in the control group with a maximum gain in weight of 5.87 kg observed around the 36''' day. Gain in others was also there but the gain in body weight was less as compared to that of the contort group. The maximum gain in weight in other groups was 2.13kg (in vitamin C supplemented group), 2.98 kg (in vitamin E supplemented group) and 1.50 kg (in vitamin C + vitamin E supplemented group). The gain in body weight was minimal in the group that received vitamin C and vitamin E. The data showed that weight gain in the subjects with vitamin supplementation of the diets was less as compared to that observed in the control group.

Body fat continuously increased in the control group with a maximum increase of 3.85% observed on the 36th clay. Similar was the trend tin the vitamin E supplemented group. But those who took vitamin C and a combination of vitamin C and vitamin E showed less increase in their body fat as compared to those who were not given anything. Incidentally, the maximum increase in body fat was 2.31 % in vitamin C supplemented group, 1.55% in vitamin E supplemented group and 4.58% in the vitamin C and vitamin E supplemented group.

Once of the consequences of rapid weight gain is the gain of body protein or lean body mass. This is especially true when the individuals are physically inactive. Maintenance oflean body mass is an energy expensive process. Lean body mass is the most metabolically active tissue in the body with respect to energy demands, accounting for the majority of calories to support the basal energy requirement (i.e., 60 to 70% of daily basal energy requirements for adults). If weight gain consists of singnificant amounts of body protein, then the normal person will have a higher basal energetic requirement and a decreased energy efficiency in terms of the weight gained as fat.

Once of the responses of free-living humans is the tendency to overeat during such initial days. This suggests that the regulation of the food intake is increased leading to gain in weight. And the signals sent ot the brain by the free living body seem to set the stage for hyperphagia, i.e., increased food intake above the normal, when food is no longer restricted. Thus, the signals are enduring because hyperphagia is a of fixed duration for an individual. The origin of these signals is not known but there is no doubt about their existence because the food intake is an event regulated by the central nervous system.

Body mass index correlates with body fatness and with the risk of overweight related diseases. Overweight is defined as a BMI between 25 and 30 and obesity is a BMI over 30. The mean BMI has been found to be between 20 and 24.5 amongst all the subjects (Table 9). The BMI continuously increased in the control and vitamin C and vitamin E groups whereas no consistent pattern was observed in the vitamin C and vitamin E groups.

However, BMI does not assess body composition per se. It only provides a basis for assessing the health risks associated or presumed to be associated with excess body fatness. While total body fat is an important risk factor for several degenerative diseases, the distribution of the stored fat may have an impact upon the progression of disease states as well especially the cardiovascular diseases. There was slight decrease in the percentage of body water in all the groups except in the vitamin E supplemented group. But the maximum decrease was observed after 36 days. The vitamin E supplemented group showed decrease in the percentage of body water only after 60 days.

Basal metabolic rate decreased in 36 days, then increased after 48 days and again decreased in the control group. BMR continuously increased upto 36 days in the vitamin E supplemented group. Thereafter, it decreased to the original level. However, BMR remained unchanged during the period of study in the vitamin C and vitamin E supplemented group.

Numerous factors capable of influencing food intake have been recognised but their relative importance and contributions to weight changes have been difficult to establish, particularly in humans, in which non-physical facotrs can markedly contribute to stabilise or alter food consumption. Whatever may be invloved, lit is evident at least that the spontaneous drive to eat provides, enough carbohydrate to maintain glycogen concentration.

O Hara's study showed a weight loss of 1.0 kg over the course of the Arctic trial. This whoel loss was due to the loss of water and the loss was regained after returning to Sithem Ontario. In other study, Wison 91960) reported a 3.0 kg loss of weight over a period of 40 days of sledging in Antarctica. Similarly, Shephard et al (1973) commented on a substantial dehydration of Eskimos observed soon after their return from Arctic hunting.

Loss of body-weight by men dog-sledgeing in polar regions has been found on many occasions. Ekelof (1904) reported losses as high as 7 kg. But Massey (1956), Lewis, Masterton and Rosenbaum (1960), Wilson (1960), Orr (1965) and Budd (1966) reported lossess of up to 8 kg. Most of these authors also reported that weight is rapidly regained after return to the home station : as much as 3 kg in the first 24 hr. The cause of this loss and subsequent regain in weight has not been established. Energy imbalance seemed to be primarily responsible in the examples quoted by Edholm (1964) and Orr (1965). However, fluid imbalance was considered important by Massey (1956), and was believed to be the main factor by Lewis et al. (1960) and Wilson (1960). The pattern of this weight

change might help to identify its cause, Grandual and progressive change would be more likely to reflect energy balance, while rapid change to subsequently stable levels would reflect fluid imbalance. With modern advancement, the use of dgo-sledging ins being replaced with automotive transport system. This would be expected to result in energy expenditure to be less. However, Hicks (1966) reported losses of up to 6 kg occurring in field parties driving enclosed, heated tractors. On the other hand, this study showed increase in body weight because of the decrease in energy expenditure. Thus, the gain in weight could be associated with an increase in the amount of food eaten rather than with any very dramatic change in water balance.

Boyd(1975) study showed that losses of weight for men using mechanical transport in the field in Antarctica are of the same order as those previously found for men using dog-sledge. The subsequent gains on return to the home station are also similar magnitude which confirms the findings of Hicks (1966).

There is still considerable difference of opinion as to what constitutes the ideal polar diet. Frazier (1945) reporting on physiological work undertaken during the establishment of little America TII staged that appetite was increased by the cold. Johnson and Kark (1947) compared the diets suitable for troops operating in the tropics and in polar regions and suggested that as much as an additional 2000 kcal/man daily or more was required by men working in the cold. Webster (1952) has calculated that men exposed to temperature of -30° F would expend as much as 1000 kcal. Iampietro et al. (1957) after conducting experiments in cold-chamber have stated that there was no evidence that cold stress imposed additional calorie requirements apart from those resulting from increased muscle activity.

Whether their large appetites are the results of climatic changes or of increased activity or of both, it is certain that men on polar expeditions need a large calorie intake if they are to maintain their body-weight. The exact calorie requirement depends on the physical strature involved. There has been a tendency in the past to overstandardize diets of that all men, large and small, active and static, have been given the same ration. Though 3000-4000 kcal/day have supplied the needs of men on base, it was found during the trials under discussion that 5500 kcal/day were just sufficient to maintain the body-weights of large men who were traveling hard.

The composition of the ideal diet is also subject to individual variations. Though the rations are more than sufficient, much of it is wasted. It was observed that most of the subjects were taking enough fat, although McLean (1919) said that fat was necessary in an Antarctic diet. Both Buston (1950) and Masterton et al. (1957) have shown that a high fat diet was well tolerated and absorbed under polar conditons. Expeditions were taking excess of butter and pure ghee in addition to what was made available to them. However, because of the less physical activity at the Maitri Station, those who were taking additional quantities of fat

started avoiding it during the later part of their stay in order to reduce the weight gained earlier.

Hence, the implication sof these findings for energy requirements of free-living subjects are difficult to assess, since under normal conditions behavioural responses depend on clothing, shelter, protection from wind and chages in intensity of physical activity. Information on the effective thermal environment of individuals as apposed to measurements of external climatic conditions might help to assess whether the effect of temperature and possibly humidity on energy expenditure should be taken into account in attempts to establish the energy requirements of different populations. At present no consideration of climatic conditons on energy expenditure of populations is advised by FAO/WHO/UN Unviersity. This is appropriate to a have this information in the present modern situation where climatic environment may have considerable effects on the energy requirements of free-living human subjects in certain situations like Antarctica and Arctic.

Water serves many functions in the body. It participates in the heat economy of the animal due to its low thermal conductivity and its high specific heat. Metabolic reactions in the cell produce heat. This heat can be absorbed by the water in the cell with no appreciable rise in temperature. The heat can the be transferred to the body surface and, through the vaporisation process, the body is cooled. Because of its high latent heat of vaporisation (586 cal/g water evporated at 0° C). evaporative water losses can account to a great extent of the total heat emissions. Under high heat stress, the total heat produced by the adult human is dissipated entirely through the vaporisation of water. This is especially true if profuse sweating occurs and the relative humidity of the environment is low. Thus, the properties of water help maintain a relatively constant body temperature even though the environmental temperature may very over a wide range.

The most important factor regarding fluid intake in the cold is the logistic constraint of fluid delivery. If drinking water or other fluids cannot be provided, dehydration will undoubtedly result. Although water in the form of snow or ice is available, relying on such sources for drinking water is unrealistic. Those who had gone out of the Maitri station for their respective assigned job for 4 to 6 h, normally carry with them 2 to 3 bottles of 1 litre capacity each of soft drinks, like pepsi or juice which they share amongst themselves during this period and it was the only fluid taken by them.

Reduced feeling of thirst also contributed to reduced body fluid which also occurred when the subjects were on outside job with little fluid with them. When the subjects were on outside job with little fluid with them. When the subjects returned to the warm station, they felt thirsty and took sufficient fluid, preferably tea/coffeee. In addition, it was observed that the subjects often voluntarily restricted fluid intake which took place late in the day to prevent the necessity of leaving the warm cabin or sleeping bag in order to go to the toilet which is lo-

cated 20-30 m away from the cabin. Thus, it is difficult to pin-point or predict a particular factor responsible for reduced body fluid.

Regardless of the methods used to estimate lean body mass, total body water and percent body liqid, it is generally agreed that the composition of the human, as well as the bodies of other species, can vary. Age, sex, degree of physical activity, and diet have all been shown to affect body composition. Diets, particularly energy rich diets which increase fat deposition, affect body composition. Diets, particularly energy rich diets which increase fat deposition, affect body composition. Brozek and Keys (1955) found that in overfed men who gained weight, 14% of the weight gain was due to an increase in extracellular fluid, 24% was an increase in cellurlar components and 62% was an increase in fat.

In an earlier study conducted by Majumdar et al. (1994), it has been observed that mean body weight and mean skinfold thickness at eleven different sites of 18 men of the IX Indian Scientific Expedition to Antarctica were increased at all the sites significantly throughout their 14 months stay at Maitri (70° 45'S, 11° 44'E). The maximum increase of mean body weight was 6.14kg. the increase of skin fold thickness was maximum at abdomen. The present study confirms this. The maximum gain in body weight was 8kg in one of the subjects during the period of study.

The blood hemoglobin concentration increased in all the groups except in those subjects who were taking additional vitamin E. The vitamin E supplemented group showed no change in the hemoglobin levels during the study period. Vitamain C supplemented group showed no change in the hemoglobin levels during the study period. Vitamin C supplemented group showed and increase in hemoglobin concentration. The Subjects who were given both vitamin C and vitmain E also showed a non significant increase in hemoglobin concentration.

The percentage of hematocrit increased in all the group except vitamin E supplemented group. With increase in RBCs. The increase in hematocrit is expected which was observed in the study. The vitamin E supplemented subjects did not show .any change in hematocrit and RBCs.

Platelet counts increased in all the group after staying at the Maitri Station. The counts decreased in all the groups but the decrease was less in Vitamin C and Vitamin C and Vitamin E together supplemented groups. The platelet aggregation was more in the control group than those supplemented with vitamin C and vitamin E.

The Antarctica continent has adverse environmental conditions such as high uv radiations, magnetic field, high wind velcity and extreme cold. These environmental conditions either alone or in combination cause many adverse effects. Exposure to extreme cold also poses problems such as frostbite. These maladies of Antarctic region are often attributed to microcirculation disturbances includ-

ing capillary permeability. All these changes might be due to the oxidant stress which is enhanced by the stressors of Antarctic regions. The body's susceptibility to free radical stress and the related damagbe is associated with overall balance between the stress level and the antioxidant potential of the human body.

Platelets constitue one of the four main components of the hemostatic system, which protects the body from the effects of trauma and preserves the integrity of blood vessels. Platelets represent a first-line defense in this system which also includes the vessel wall, and the coagulation systems. Upon activiation, platelets become very stickly, adhere to a variety of surfaces and to each other, and their membrane allows rapid activation of certain coagulation factors. The stimuli that activate platelets are manifold.

Vitamin E may trap chain reaction started by oxygen radicals of endogenous or exogenous origin (e.g., produced as byproducts of normal metabolism or after infections, or caused by mitroso compounds or by radiation), thus protecting cells from lipid peroxidation (Ames 1983). It may also trap secondarily propagated radicals from the chain reaction of polyunsaturated fatty acids peroxidation and exogenous radicals caused by environmental agents (Grey 1986).

Lipid and carbohydrate metabolism have been shown to play an important role during cold exposure. When body heat loss is greatly increased by exposure to the cold, high rates of lipid and carbohydrate oxidation are essential to maintain an increased metabolic rate (Himms Hagen 1972, Thomposon 1977, Vallerand et al. 1988. Allerand and Jacobs 1989). Indeed, cold exposure in animals has been shown to increase plasma glycerol and free fatty acid (FFA) levels, FFA turnover, glucose tolerance, glucose turnover, peripheral glucose uptake, and glucose oxidation (Himms-Hagen 1972, Thompson 1977, Vallerand et al. 1988, Depocas and Massironi 1960, Vincent-Falquet et al. 1972). In humans, it has been shown that carbohydrate oxidation is significantly increased during cold exposure, and that this increase was dependent on a greater utilization of both plasma glucose and muscle glycogen (Vallerand et al. 1988, Marti neau and Jacobs 1988). In contrast, lipid utilization and the source of oxidized lipids have not been extensively examined in cold-exposed man. However, the triglycerides levels decreased in the mean exposed to the cold. This has also been observed by vallerand al. (1988). Total cholesterol increased in the vitamin C supplemented group after 15 days at Maitri Station whereas triglycerides level decreased. The cholesterol levels decreased after 60 days whereas triglycerides level also decreased.

There are three main depots from which lipid substrates can be dervied (Holloszy et al. 1986) The first depot consists of the FFA plasma pool, which is dervied mainly from white adipose tissue triglycerides (TG). The second lipid pool is found in small fat droplets within the skeletal muscle fibres. The intramuscular fatty acids are made available for oxidation after hydrolysis by a hormone-sensitive lipase. The last depot consists of the TG-carrying plasma lipoproteins

intracapillary lipoprotein lipase that is found mainly in skeletal muscle and white adipose tissue. Recent studies suggest that acute prolonged exercise greatly enhanced lipid metabolism through an increased utilization of lipid from all three fat depots. Indeed, exercise increases plasma glycerol levels, plasma FFA turnover (Paul and Holmes 1975), plasma TG utilization et al. 1987) as well as intramuscular TG utilization (Holloszy et al. 1986, spriett et al. 1985). Whether all three fat depots contribute to the enhanced energy requirements of the human skeletal muscle during prolonged exposure to cold is not known. However, what is known is that intramuscular TG utilization and VLDL turnover are both increased druing shivering in rats (Radomski and Orme 1971, Theriault and poe 1965) and that in dogs, plasma FFA is thought to represent the major source of fatty acids for oxidation in the cold (Vincent-Falquet et al. 1972).

In marked contrast.the importance of FFA for the cold-induced increase in lipid oxidation has been questioned in recent human studies, where it was shown that cold exposure increase lipid oxidation even when FFA utilization is markedly reduced by the ingestion of nicotinic acid (Martineau and Jacobs 1989).

Vitamin E is known to prevent the formation of peroxides and it was suggested that vitamin E might prevent the peroxidation of arachidonate in platelets, perhaps at the step of phospholipase A activation of the conversion of arachidonic acid into cyclic endo-peroxides by cyclo-oxygenase. Another possibility is that lipid peroxidases accumulatedin the vessel wall might inhibit PG12 synthetase. This received support from a study by Okuma et al. (1980) showing that the release of a prostacyclin-like substance from aortic rings was significantly reduced in vitamin E deficient rats. This effect was reversed by feeding a vitamin E supplemented diet.

Based on the finding that platelet release reaction is associated with a sudden increase in lipid peroxidation and the ability of a-tocopherol to reduce the rate of lipid peroxidation in stored platelet suspensions. Stenier and Anastasi (1976) investigated the influence of added vitamin E on platelet aggregation. Inhibition of the platelet release reaction in responses to ADP, collagen and epinephrine in the presence of addes a-tocopherol was shown by the abolition of the secondary wave of aggregation and the decrease in aggreation-induced release of 5hydoxy[12C] tryptamine from prelabelled platelets. Oral vitamin e was shown in this study to increase the plasma and platelet vitamin E concentrations but the effect on platelet aggregation was not reported.

The effect of vitamin C deficiency on platelet function has been examined both in experiemental animals and in man. The in fluence of ascrobic acid on platelet function was assessed by Sarji et al. (1979). The addition of ascorbic acid to platelet rich plasma to a concentration of 1000 ug/ml inhibited platelet aggregation in response to ADP, epinephrine and collagen, but enhanced aggregation induced by arachidonic acid. In the same study, the oral administration of ascorbic acid to volunteers (2g daily for seven days) markedly inhibited platelet aggregation. Proposed mechanism for the inhibition of platelet aggregation by

ascorbic acid included inhibition of cyclo-oxygenase and a rise in the level of cyclic AMP. Similar findings have been observed by Cordova et al. (1982), i.e., inhibition of platelet aggregation and reduced production of malondialdehyde was seen after the addition of ascorbic acid to platelet rich plasma and after the intrave3nous administration of 2g ascorbic acid to healthy subjects.

Free radical formation, the consequence of oxidative stress, might be expected to increase in cold environments due to the elevation in metabolic rate that results from an increased energy expenditure and the increased exposure to ultraviolet radiation on snow-covered ground. During a polar expedition, an increcrease in production of malonaldehyde, a product of lipid peroxidation believed to be a marker for oxidative stress, was measured in erythrocytes and plasma, followed by decreased blood concentration of vitamin E (Panin et al. 1992 as reported by Askew 1995). In contrast to this, it was observed that plasma uric acid decreased in the control group whereas it remained practically unchanged in those supplemented with vitaim C and Vitamin C an vitamin E, probably due to well protected from the cold.

Y- Glutamyl transferase levels increased in all the subjects except in the subjects which received vitamin C. Also the increase was less in the vitamin E supplemented subjects as compared to other subjects. Cholinesterase activity in plasma remained practically unaltered in all the groups except those subjects which did not receive any treatment. In fact, the activity of cholinesterase decreased. Uric acid concentration pattern was similar to the cholinesterase activity, that is, the concentration of uric acid decreased continuously in the control subjects whereas the levels of uric acid remained practically constant clue to supplementation of vitamin C and vitamin E.

In conclusion, the major finding to emerge from this study was that a relatively simple and unobstructive supplementation with common antioxidants, i.e., vitamin C and vitamin E to the already present in the food supplied has the potential to produce significant beneficial effects on members of the Antarctic Expedition, thus educing the instances of diseases associated with overweight and overfeeding due to free living at Antactica as the facilities now existing at the Antarctica have large removed the need for cold acclimatization.

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Table 1

Age (years) and height (cm) of members of the XVT Indian Scientific Expedition to Antarctica

Groups	Age	Height
Control	38.12 + 2.29	167.62 + 2.98
Vitamin C	37.75 + 2.49	168.25 + 1.45
Vitamin E	37.37 + 2.03	169.00+ 1.65
Vitamin C + Vitamin E	37.75 + 2.34	166,37+ 1.46

Values are mean + standard error of the mean of 5-8 subjects.

Table 2

Effect of supplementation of vitamin C and vitamin E on variation in body weight (kg) of members of the XVI Indian Scientific Expedition to Antarctica

Groups/Days	0	12	24	36	48	60
Control	58.63±1.98	59.60+1.40	62.60+2.14	64.50+2,75	60.75+1.74	63.00+2.68
Vitamin C	59.37+2.84	61.60+2.70	61.75+3,37	61.50+2.81	53.57+2.50	62.66+3.41
Vitamin E	61.68+2.08	64,33+1.92	62.90+1.94	64.66+1.95	63.90+1.06	64.75+1.83
Vitamin C +Vitamin E	61.50+3.84	59.16+3.35	63.80+3.26	63.00±3.73	67.25+3.34	62.75+2.18

Values are mean + standard error of the mean of 5-8 subjects.

Table 3

Effect of supplementation of vitamin C and vitamin E on variation in body fat weight (per cent) of members of the XVI Indian Scientific Expedition to Antarctica

Groups/Days	0	12	24	36	48	60
Control	20.90+1.16	21.08+1.55	23.38±1.28	24.75+1.42*'	20.22±1.68	23.12+0.89
Vitamin C	21.37+1.23	24.76+0.69	21.60+1.15	23.51+1.91	23.36+0.98	23.43+0.92
Vitamin E	21.81+1.49	22.05+1.60	22.24+1.94	23.36+3.06	25.10+3.21	26.77+1.38'
Vitamin C + Vitamin E	23.37+1.54	24.18+1.17	23.35+1.31	27.95+1.84	25.15+1.16	26.00+0.89

Values are mean + standard error of the mean iof 5-8 subjects.
• p<0.01
** p<0.02

Table 4

Effect of supplementation of vitamin C and vitamin E on variation in body fat weight (kg) of members of the XVI Indian Scientific Expedition to Antarctica

Groups/Days	0	12	24	36	48	60
Control	12.25+0.92	12.80+1.07	15.00+1.20	16.00+0.80*	13.66+0.82	14.60±1.02
Vitamin C	!2.75±1,10	15.40+0.77	13.75+1.40	14.33+1.40	14.83+0.88	14.66+1.06
Vitamin E	13.50±1.15	14.50+1.40	14.00+1.11	15.00+1.76	15.80+2.03	17.00+0.71
Vitamin C + Vitamin E	14.62+1.70	14.50+1.20	15.33+1.42	17.57+1.60	17.00+1.60	16.50+0.88

Values are mean + standard error of the mean of 5-8 subjects
* p<0.05

Table 5

Effect of supplementation of vitamin C and vitamin E on variation in body water (per cent) of members of the XVI Indian Scientific Expedition to Antarctica

Groups/Days	0	12	24	36	48	60
Control	60.80+1.88	60.20+2.16	57.48+1.73	55.35+1.97	61.97+2.30	57.58+1.02
Vitamin C	60.40+1.86	55.58+0,79	59.85+1.63	57.98+2.41	57.43±1.30	57,31+1.19
Vitamin E	59.05+2.33	59.13+2.09	59.56±2.32	58.70+3,62	56.90+4.14	53.50+1.55
Vitamin C + Vitamin E	57.52+2.28	56.28+1.70	57.48+1.70	51.87+1.92	55.25+1.27	53,82±1.15

Values are mean + standard error of the mean of 5-8 subjects.

Table 6

Effect of supplementation of vitamin C and vitamin E on variation in volume of water in the body (1) of members of the XVI Indian Scientific Expedition to Antarctica

Groups/Days	0	12	24	36	48	60
Control	35.37+1.16	35.80+1.18	35.80+0.81	35.50+0.25	37.50+1.09	36.20+1.42
Vitamin C	35.62±1.28	33.20+1.12	36.75+1.51	35.33+1.97	36.33+1.72	35.83+1.85
Vitamin E	36.50+1.40	37.83+0.82	37.40+1.96	38.00+2.76	36.40+2.95	34.75+1.76
Vitamin C + Vitamin E	34.87+1.44	33.16+1.81	36.50+1.31	32.71+2.25	37.00+1.50	33.75+1.33

Values are mean + standard error of the mean of 5-8 subjects.

Table 7

Effect of supplementation of vitamin C and vitamin E on variation in lean body mass (kg) of members of the XVI Indian Scientific Expedition to Antarctica

Groups/Days	0	12	24	36	48	60
Control	46.25+1.46	46.80+1.09	47.60+1.29	48.50+1.25	48.50+1.10	48.40+1.84
Vitamin C	46.62+1.95	46.20+2.08	48.00+2.12	46.83+2.40	48.50+2.83	48.00+2.51
Vitamin E	48.12+1.60	49.83+0.93	48.80+2.04	49.66+2.74	48.00+2.53	47.75+2.12
Vitamin C + Vitamin E	48.87+2.27	44.66+2.38	48.61+2.07	43.42+3.11	50.25+2.02	46.25+1.64

Values are mean + standard error of the mean of 5-8 subjects.

Table 8

Effect of supplementation of vitamin C and vitamin E on variation in lean body mass (per cent) of members of the XVI Indian Scientific Expedition to Antarctica

Groups/Days	0	12	24	36	48	60
Control	79.08+1.16	78.92+1.55	76.62+1.28	75.75+1,67	79.60+1.59	76.87+0.81
Vitamin C	80.08+2.15	75.24+0.69	78.40+1.15	76.40+1.91	76.61+0.98	76.56+0.92
Vitamin E	78.15+1.46	77.95+1.60	77.76+1.93	72.04+3.06	74.90+3.21	73.22+1.38'
Vitamin C + Vitamin E	76.62+1.53	75.81+1.17	76.58+1.27	72.04+1.84	74.85+1.16	74.00+0.88

Values are mean + standard error of the mean of 5-8 subjects.
* $p<0.05$

Table 9

Effect of supplementation of vitamin C and vitamin E on variation in body mass index (kg/sq m) of members of the XVI Indian Scientific Expedition to Antarctica

Groups/Days	0	12	24	36	48	60
Control	20.91+0.07	21.13+0.61	21.57+0.76	21.90+0.74	21.70+0.96	22.18+1.06
Vitamin C	20.98+1.01	21.81+1.03	21.61+0.89	21.84+0.89	22.32+0,97	22.23+1.11
Vitamin E	21.60+0.74	22.06+0.70	21.47+0.59	22.26+0.53	22.82+0.61	23.21+0.47
Vitamin C + Vitamin E	22.17+1,26	21.33+1.03	22.62+1.03	22.77+1.20	24.23+0.71	23.03+0.67

Values are mean + standard error of the mean of 5-8 subjects.

Table 10

Effect of supplementation of vitamin C and vitamin E on variation in basal metabolic rate (calories) of members of the XVI Indian Scientific Expedition to Antarctica

Groups/Days	0	12	24	36	48	60
Control	1604.9+54.3	1556.2+31.7	1579.2+29.1	1547.0±7.5	1606.3+32.3	1568.0+41.9
Vitamin C	1550.9+37.7	1515.8+40.9	1584.2+44.5	1542.5+58.1	1571.8+50,8	1557.0+54.8
Vitamin E	1576.7+41.3	1615.8±24.1	1611.4+52.6	1621.0+81.3	1573.8+86.9	1525.3+52.0
Vitamin C + Vitamin E	1528.7+42.6	1478 7+53.2	1576.7+38,8	1465.1+66.3	1591.5+44.2	1495.7+39.2

Values are mean + standard error of the mean of 5-8 subjects.

Table 11

Effect of supplementation of vitamin C and vitamin E on hematological indices of members of XVI Indian Scientific Expedition to Antarctica

Indices/Period/Groups		Control	Vitamin C	Vitamin E	Vitamin C + Vitamin E
HCT	0	40.70+1.75	42.16 + 2.87	40.42 + 1.25	42.83+0.86
	30	42.80+1.10	42.60 + 0.81	41,94+0.55	44.37+1.02
	60	44.47 + 1.29	45.08 + 0.99	41,20+0.69	45.14 + 0.77
HOB g/dl	0	14.85+0.35	15.01+0.20	14.65+0.31	15.73+0.24
	30	15.72+0.38	15.87 + 0.45	14.74+0.23	15.87 + 0.35
	60	15.57+0.60	16.86+0.16"	14.00+0.28	16.04 + 0.31
WBC $x10^3/\mu l$	0	6.55 + 0.39	6.56 + 0.45	6.90+0.96	6.78 + 0.45
	30	7.34+0.24	6.00+0.41	S.84+0.36	6.17+0.12
	60	6.30+0.39	6.52 + 0.34	6.90+0.89	6.85+0.16
RBC $x10^6/\mu l$	0	4.66+0.23	4.52 + 0.25	4.45 ±0.16	4.69+0.18
	30	5.07 + 0.11	4.54+0.10	4.68 ±0.10	4.54+0.18
	60	4.99 + 0.10	4.84 + 0.11	4.54+0.10	4.84+0.14
MCV f1	0	87.62 + 2.02	93.08+1.22	91.04 + 1.31	91.81+2.72
	30	87.06 + 1.93	93.89 + 1.89	89.65 + 0.82	97.07 + 2.31
	60	88.89+1.47	92.68 + 1.53	90.71+0.84	9.1.89 ±2.15
MCH Pg	0	33.25+2.36	33.72 + 1.51	33.12 + 0.92	33.71 +1.22
	30	30.84 + 1.02	35.00+0.73	31.54 + 0.61	35,I5±1,3I
	60	31.12+0.84	33.08+0.82	32.60+0.37	33.72 ±1,05
PLT x10V(U	0	191.2+13.5	197.1 + 14.2	233.4 + 29.0	237.5+14.8
	30	230.0+19.2	232.7 + 17.9	224.8 + 15.4	292.2+15.3*
	60	161.0 + 31.3	215.6 + 23.5	183.0+17.7	253.2 ± 7.0

Values are mean + standard error of the mean of 4-8 subjects
* $p<0.05$
** {K0.001

Table 12

Effect of supplementation of vitamin C and vitamin E on changes in plasma cholesterol (mg/dl) of members of the XVI Indian Scientific Expedition to Antarctica

Groups/Days	0	30	60
Control	131.48+8.70	131.94 + 11.05	132.84 + 17.53
Vitamin C	140.16 + 10.77	160.07+17,02	128.91 +15.34
VitaminE	154.19+13.25	147.19+18.63	154.25 + 18.09
VhaminC +Vitamin E	144.16+11.08	140.12+14.02	128.59+13.17

Values are mean + standard error of the mean of 4-8 subjects.

Table 13

Effect of supplementation of vitamin C and vitamin E on variation in plasma HDL-cholesterol (mg/dl) of members of the XVI Indian Scientific Expedition to Antarctica

Groups/Days	0	30	60
Control	33.141+2.734	43.182 + 2.091	46.404 + 4.043
VitaminC	26.737 + 1.965	39.627 + 2.709**	39.479 + 3.123*
VitaminE	30,199 + 2.500	41.089 + 4.224*	39.263 + 2.190**
Vitamin C +Vitamin E	36.381 + 3.148	42.259 + 4.687	31.709 + 2.367

Values are mean + standard error of the mean of 4-8 subjects.
* $p<0.01$
** $p<0.02$

Table 14

Effect of supplementation of vitamin C and vitamin E on changes in plasma triglycerides levels (mg/dl) of members of the XVI Indian Scientific Expedition to Antarctica

Groups/Days	0	30	60
Control	102.349+ 6.773	85.880 + 14.379	82.012 + 25.353*
Vitamin C	127.969+17.524	102.708 + 17.130	74.717 + 7.7036"
Vitamin E	139.909 + 16.487	78.457 + 7.255"	97.021 + 19.412
Vitamin C + Vitamin E	151.837+14.961	95.938 + 9.695"*	84.913+ 17.607**

Values are mean + standard error of the mean of 4-8 subjects.
* p<0.05
** p<0.02
*** p<0.001

Table 15

Effect of supplementation of vitamin C and vitamin E on variation in plasma *y*-glutamyl transferase activity (IU/1) of members of the XVI Indian Scientific Expedition to Antarctica

Groups/Days	0	30	60
Control	12.015+ 1.920	10.959+1.553	15.336 + 3.170
Vitamin C	15.058 + 2.596	12.632 + 2.855	16.879 + 2.101
Vitamin E	11.974 + 0.999	10.148 + 1.087	14.529 + 0.846
Vitamin C + Vitamin E	14.693 + 3.425	13.957+1.517	22.432 + 2.211

Values are mean + standard error of the mean of 4-8 subjects.

Table 16

Effect of supplementation of vitamin C and vitamin E on variation in plasma cholinesterase activity (IU/1) of members of the XVI Indian Scientific Expedition to Antarctica

Groups/Days	0	30	60
Control	3231.1+237.3	3303.6±293.I	2220.8 + 351.0*
Vitamin C	2810.6 + 249.5	2880.3+297.8	3218.5+404.8
VitaminE	3056.8 + 342.8	3232.9 + 318.4	3271.1 ±432.1
Vitamin C + Vitamin E	2822.3 + 149.2	2960.7 + 134.5	3101.7 + 301.4

Values are mean + standard error of the mean of 4-8 subjects.
* $p<0.05$

Table 17

Effect of supplementation of vitamin C and vitamin E on changes in plasma uric acid levels (mg/dl) of members of the XVI Indian Scientific Expedition to Antarctica

Groups/Days	0	30	60
Control	4.935 + 0.421	4.733 + 0.759	3.375 + 0.471*
Vitamin C	5.480 + 0.507	5.870 + 0.269	5.723 + 1.024
VitaminE	5.435 + 0.583	5.552 + 0.483	5.810 + 1.097
Vitamin C +VitaminE	4.627 + 0.488	5.472 + 0.787	4.839 + 0.497

Values are mean + standard error of the mean of 4-8 subjects.
* $p<0.05$

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