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Changes in Leptin and Neuropeptide Y in Team Members of Indian Antarctic Expedition

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Abstract

Antarctic expeditioners face different extremes of environmental conditions along with social isolation and sexual deprivation, which create a combination of physico-social factors that complicate normal human activity at a polar station. Adaptation in that new condition is always associated with some metabolic changes with alteration in nutritional requirements and utilisation. The present study was undertaken with the aim to assess the changes in appetite regulatory peptides i.e. leptin and neuropeptide Y and to know actual energy intake and expenditure of the Antarctic expeditioners. The study was conducted in three phases viz. Phase I at Goa (basal), Phase II 48h after reaching Antarctica and Phase III after one month of stay at Antarctica. Blood samples were collected in each phase for biochemical estimations. Energy and nutrient intake were analysed from the duplicate plate samples of the expeditioners. Energy expenditure was computed using Time and Motion Study. It was observed that after reaching Antarctica the expeditioners have very active life style and the total energy expenditure was found to be 3120 ± 474 kcal/day. The actual energy intake was found to be 3911 ±310 kcal/ day. This indicates that the very reason for the body weight gain was positive energy balance and not the sedentary life style. Studies on appetite regulatory peptides viz. leptin and neuropeptide Y were attempted first time in extreme environmental conditions of Antarctica. After reaching Antarctica plasma leptin levels (mean ± SEM) decreased from normal basal values 5.66 (± 0.59) ng/ml (Phase I) to 4.40 (± 0.37) ng/ml (Phase II), even though there was an increase in body fat. Concomitantly there was increase in plasma neuropeptide Y levels from 0.303 (± 0.004) ng/ml to 1.211 (± 0. 27) ng/ml ($p<0.001$). The changes observed in leptin and neuropeptide Y levels may be responsible for increase in appetite and gain in body weight at Antarctica

Keywords: Antarctica, leptin, neuropeptide Y, energy intake, energy expenditure, boy weight.

Introduction

Human sojourn to various inhospitable places i.e. Arctic, Antarctic, high altitude, tropics, space etc.Different places have their own environmental features. Problems in Antarctica stem out of extreme cold, low humidity, almost continuous snowstorms, the strong down slope and hurricane winds, the long polar days and nights, the high level of cosmic radiation, magnetic storms and increased ionisation. In addition to these environmental factors, the marked sensory deprivation, social isolation and sexual deprivation create a combination of physico-social factors that complicate normal human activity at a polar station.

Observations concerning the influence of cold climates on food intake or body weight have frequently been at variance. An increase in caloric intake during winter has been, reported by Milan and Rodahl (1961), while observations made by Easty (1967) in Antarctica indicate a marked fall. Some workers reported increase in total body weight along with body fat during residency in Antarctica both in summer and winter (Majumdar et al., 1994; Satija et al., 1998), whereas others have reported loss in body weight during Antarctic expedition (Wilson, 1960; Hicks, 1966).

Leptin, the product of the *ob* gene, was first, identified as an adipocyte-secreted protein (Zhang et al., 1994), but is also produced by the placenta and stomach (Masuzaki et al., 1997(a); Bodo et al., 1998). Circulating leptin inform the brain about adipocyte mass, thereby controlling appetite and body weight homeostasis (Halaas et al., 1995; Pelleymounter et al, 1995). Plasma leptin concentration correlates with fat mass and body mass index (BMI) in human (Halaas et al., 1995; Pelleymounter et al., 1995). The circulatory levels of leptin are also, correlated with body weight and circulating insulin (Segal et al., 1996; Zimmet and Collier, 1996). Leptin levels exhibited a circadian variation and show a peak at about 0200-0300 hrs. This nocturnal peak exceeds daytime values by about 30-100% and is present in both rodents as well as human beings (Sinha et al., 1996).

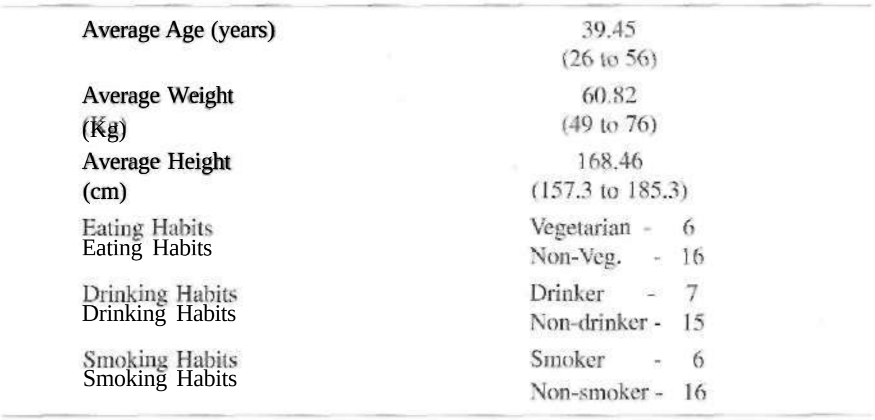
Neuropeptide Y (NPY), a 36 amino acid peptide, is, believed to play an important role in the hypothalamic mediation of energy balance in rodent (Frankish et al., 1995). It is the most abundant neuropeptide in the central and peripheral nervous system and has been shown to have powerful effects on feeding, anxiety, circadian rhythm, reproduction, pituitary adrenocortical axis function, memory retention, seizures, thermoregulation, cardiovascular and gastrointestinal functions (Grundemar, 1997). Reduction in endogenous NPY leads to a decrease in food intake, and the ARC-PVN NPY pathway is activated in response to starvation and body weight loss, as well as in genetic models of obesity and diabetes mellitus (Leibowitz, 1995; Kalra, 1997; Hemricbs et al, 1998; Woodetal., 1998).

The leptin and Neuropeptide Y has marked effect on food intake and body weight. Since in the Antarctic expeditioners, the increase in food intake, body weight and body fat have been reported (Majumdar et al., 1994; Satija et al., 1998), the present study, was undertaken to see the changes in leptin and neuropeptide Y levels in human volunteers at Antarctica and their role in regulation of appetite, food intake and change in body weight and to know the actual energy intake and expenditure of the volunteers at Antarctica.

Methods and Materials

The study was conducted on 22 healthy male volunteers of Indian Antarctic Expedition of the age group of 26 to 56 years. The weights of the subjects vary from 49 Kg to 76 Kg and heights from 157.3 cm to 185.3 cm (Table 1). The study was conducted in Austral summer in the months of December to February. Written consent was obtained after giving full details of protocol approved by the Institute's Ethic Committee.

Table 1: Physical characteristic and habits of the subjects



Average Age (years)	39.45 (26 to 56)
Average Weight (Kg)	60.82 (49 to 76)
Average Height (cm)	168.46 (157.3 to 185.3)
Eating Habits	Vegetarian - 6 Non-Veg. - 16
Drinking Habits	Drinker - 7 Non-drinker - 15
Smoking Habits	Smoker - 6 Non-smoker - 16

The study was conducted in three phases. Initial base line data was collected at Goa (Phase I). After the initial study subjects were taken to Cape Town by air and after that by sea route to Antarctica. The study was conducted 48h after reaching Antarctica (Phase II) and after one-month stay in Antarctica (Phase III).

The ambient temperature at Goa during the study period ranges from 24 to 35 °C. During sea journey the ambient temperature ranges -3 to 30 °C but inside the cabins, temperature was maintained at 20 + 2 °C. During sea journey, most of the time subjects confined within living space i.e. living room, entertainment room or dinning room. In Antarctica study was conducted at Indian Antarctic Station (Maitri). Maitri is situated on the rocky area of Schirmacher Range at the Latitude 70° 45'56.902288 S and Longitude 11° 44' 8.620111 E. During the study period at Maitri the ambient temperature ranges between -9.2 °C to +5 °C. Maximum wind velocity goes upto 93 Km/h with an average of 29.34 Km/h. The clear sky was only for seven days and there was snowfall on 5 different days. Subjects lived in Summer Huts (12 persons per hut) made up of wood. Oil heaters were provided to heat the huts and the inside temperature was maintained at 20 + 2 °C. Though the inside temperature was maintained at 20 ± 2 °C the subjects had a good exposure of cold also.

Assessment of food consumption

Total energy intake was computed from actual food analysis. Duplicate food samples for various meals i.e. break fast, lunch and dinner collected on random basis, from the plates of the subjects just prior to the started eating. This was done on several different days so as to cover the entire menu. These samples were measured and analysed for protein, fat, carbohydrate and for total calorific value.

Assessment of energy expenditure

Total energy expenditure was computed by recording the daily activities of the subjects. The energy cost of each task performed by these subjects was taken from earlier studies of this Institute (Malhotra et al., 1962; Sridharan et al., 1987). The average time spent in each activity by these subjects was calculated using "Time and Motion Study" method. In this method subjects were asked to continuously record their daily activities over 24h, on a Time and Motion form issued to them, for one week. The energy expenditure of various activities were classified as per the method of Passmore and Durnin (1955).

Assessment of body composition

Body weight and height were taken empty stomach early in the morning. Body fat, body water and total body minerals were measured by Bioelectric Impedance Analysis method using Maltron Body Fat Analyser, BF-906, Maltron International Ltd., England.

Biochemical estimations

Blood samples were collected initially at Goa for baseline data, 48h after reaching Antarctica and after one-month stay in Antarctica. Blood samples were collected between 7-9 AM from antecuital vein after overnight fast. Plasma was separated using heparin as anticoagulant immediately after the blood collection and stored at -20 °C.

Plasma leptin and neuropeptide Y were estimated using EIA kits supplied by dbc- Diagnostics Biochem Canada Inc., Canada and Peninsula Laboratories, Inc, USA respectively. Plasma protein was assayed using method by Lowry et al. (1951). Plasma total cholesterol, HDL cholesterol and triglycerides were estimated using diagnostic kits by Transasia Bio-Medicals Ltd, India and plasma Insulin levels were estimated using ELISA kit supplied by Diagnostic Systems laboratories, USA.

Statistical Analysis

Data analysed statistically to find out significant difference between various phases of study using one way ANOVA and post hoc testing with least significant difference (LSD) and a p value <0.05 was considered significant.

Results

A positive energy balance of 791 kcal/day/person was observed during the study in Antarctica. Average energy intake was 3911 + 310 kcal/day/person. The energy distribution between various nutrients was carbohydrates- 52.5%, fat- 35.7% and protein 11.8%. The average energy expenditure was 3120 ± 474 kcal/day/person. Percentage energy consumption in various type of activities were - very light 35.1%, light 16.6%, moderate 14.3% and heavy 34.0% of the total average energy expenditure per day per person (Tables 2 & 3).

Table 2: Energy intake and expenditure of the subjects in Antarctica

Energy Intake (kcal/d)	Energy Expenditure (kcal/d)	Energy Balance (kcal/d)
3911 ± 310	3120 ± 474	+791
Energy Contributed by:	Type of activities:	
Carbohydrate - 52.5%	Very Light - 35.1%	
Fat - 35.7%	Light - 16.6%	
Protein - 11.8%	Moderate - 14.3%	
	Heavy - 34.0%	

Values are Mean ± SEM, n = 10

Table 3: Daily average energy expenditure by the subjects in various grades of activities in Antarctica

Type of Activity	Energy Cost (kcal/min)	Time Spent (min)	Energy Expenditure (kcal)
Very Light	1.0 to 2.0	886.8 ± 88.8	1095.9 ±65.4
Light	2.1 to 3.0	195.0 ± 72.8	516 ± 112.1
Moderate	3.1 to 4.0	113.7 ± 16.9	446.7 ± 56.6
Heavy	4.1 to 6.0	224.3 ±101.0	1061.6 ±240.0
Total		1440	3120.8 ±474

Values are Mean ± SEM, n = 10

An increase of 2.15 Kg in mean body weight was observed after reaching Antarctica which was statistically significant ($p<0.001$). A further increase of 1.03 Kg in mean body weight was observed after one-month stay at Antarctica. The total average weight gain by the volunteers between Phase I and III was 3.18 Kg (Table 4).

Subjects gain an average of 1.69 Kg body fat during voyage to Antarctica. During stay at Maitri a further gain of 1.05 Kg in mean body fat was observed. This gain in body fat makes the total mean gain of 2.74 Kg in comparison to initial body fat. The body fat increase in Phase II and III in comparison to initial and increase in Phase III in comparison to Phase II are statistically highly significant ($p<0.001$, $p< 0.001$ and $p< 0.01$ respectively). Body fat percent of body weight also showed an increasing trend and the percent gain in body fat were 2.21 and 3.57 in Phase II and Phase III respectively. This percent change in body fat is highly significant ($p<0.001$) (Table 4).

Table 4: Body weight and body fat in different phases at Goa and in Antarctica

	Phase I	Phase II	Phase III
Body Weight (Kg)	60.82 ± 1.61	62.97 ± 1.58***	64.00 ± 1.66***$^{+}$
BodyFat(Kg)	11.42 ± 1.03	13.11 ± 0.98***	14.16 ± 0.91***$^{++}$
Body Fat % of Body Weight	18.37 ± 1.25	20.58 ± 1.18***	21.94 ± 1.04***$^{++}$

Values are Mean ± SEM, n = 22
*** $p< 0.001$, Phase I vs Phase **II** & **III**
+ $p<0.05$, ++ $p<0.01$, Phase **II** vs Phase **III**

An increasing trend in body mass index was observed in subjects after ship journey and after one month stay in Antarctica. An average increase of 0.71 and 1.14 was observed in Phase II and III respectively in comparison to initial base line values (Phase I). This increase is statistically significant ($p<0.01$, Phase II and $p< 0.001$ Phase III) (Table 5).

Table 5: Body mass index, lean body mass, body mineral and resting metabolic rate in different phases at Goa and in Antarctica

	Phase I	Phase II	Phase III
Body Mass Index	22.11 ± 1.61	22.82 ± 0.53**	23.25 ± 0.51^{***+}
Lean Body Mass (Kg)	49.45 ± 1.08	49.86 ± 0.53	49.83 ± 1.12
Lean Body Mass (% of Body weight)	81.60 ± 1.31	79.45 ± 1.23***	78.02 ± 1.09^{***++}
Total Body Mineral (Kg)	3.50 ± 0.11	3.48 ± 0.11	3.47 ± 0.10
Total Body Water (Litre)	36.72 ± 0.91	37.10 ± 0.93	36.82 ± 0.92
Total Body Water (% of Body Weight)	59.16 ± 1.05	57.48 ± 0.96***	56.62 ± 0.87^{***+}
Resting Metabolic Rate (kcal)	1504.33 ± 44.27	1532.85 ± 44.19***	1543.33 ± 43.72***

Values are Mean ± SEM, n = 22
** $p<0.01$, *** $p<0.001$, Phase I vs Phase II & III
+ $p< 0.05$, ++ $p< 0.01$, Phase II vs Phase III

A decrease of 22.26% in plasma leptin level was observed in volunteers after reaching Antarctica (Table 6). But after a stay of one month in Antarctica (Phase III), a highly significant ($p<0.01$) increase (70.22%) was observed in plasma leptin level in comparison to Phase II.

Table 6: Plasma leptin, neuropeptide y, insulin and total protein levels of subjects in different phases at Goa and in Antarctica

	Phase I	Phase II	Phase III
Leptin (ng/ml)	5.66 ± 0.59	4.40 ± 0.37	7.49 ± 1.18^{++}
Neuropeptide Y (ng/ml)	0.303 ± 0.004	1.211 ± 0.27***	0.14 ± 0.14^{*+++}
Insulin (μIU/ml)	17.27 ± 1.05	16.92 ± 1.07	17.65 ± 1.62
Total Protein (g/dl)	7.08 ± 0.18	7.43 ±0.11	7.76 ± 0.16**

Values are Mean ± SEM, n= 22
* $p<0.05$, ** $p< 0.01$, *** $p< 0.001$, Phase I vs Phase II & III
++ $p<0.01$, +++ $p< 0.001$, Phase II vs Phase III

This level was about 32% higher than the initial value. These changes in plasma leptin levels are statistically significant (ANOVA, p = 0.0067).

About four-fold increase was observed in plasma neuropeptide Y level in Phase **II** in Antarctica (Table 6). The increase was statistically significant ($p<0.001$). However, subjects could not maintain this high level of plasma NPY during further stay in Antarctica. After one-month stay, a drastic decrease in NPY level was observed. This decrease was also statistically significant in comparison to both initial Phase I ($p<0.05$) and Phase II ($p<0.001$) level. Increased (-5%) level of plasma protein was observed in subjects immediately after reaching Antarctica. A further significant ($p<0.01$) increase was observed in plasma protein after one-month stay in Antarctica (Table 7).

Table 7: Plasma lipid profile in different phases at Goa and in Antarctica

	Phase I	Phase II	Phase III
Total Cholesterol (mg/dl)	147.67 ± 7.14	155.17 ± 7.82	158.71 ± 9.92
HDL-Cholesterol (mg/dl)	31.14 ± 1.70	42.47 ± 2.98***	43.99 ± 2.82***
LDL-Cholesterol (mg/dl)	125.66 ± 10.80	112.70 ± 8.12	117.12 ± 9.82
Triglyceride (mg/dl)	95.93 ± 9.62	83.19 ± 8.79	98.15 ± 8.27

Values are Mean ± SEM, n= 22
*** $p< 0.001$, Phase I vs Phase II & III

Phase I Phase II Phase III
158.71 ± 9.92
43.99 ± 2.82***
117.12 ±9.82
98.15 ±8.27
Values are Mean ± SEM, n= 22
*** p< 0.001, Phase I vs Phase II & III

Discussion

Adaptation to environmental extremes can exert profound influences on human physiology. Success or failure to adapt in adverse environmental extremes is determined by how well the body responds to the challenges of maintaining homeothermia and work out put. The intake and expenditure of energy in individual, must balance otherwise a change in total body store is definite to occur. Changes in body weights are considered as reflection of energy change in the present study. The significant increase in the mean body weight of subjects in Phase II and **III** of the study is due to the positive energy balance. The difference between the mean daily energy intake and expenditure was +791 kcal. Since the subjects had very active life style before the expedition and during the expedition period and involved in different jobs inside or outside the station to maintain the station and for scientific research, resulting in sufficient cold exposure to alter the hormones metabolism responsible for food intake and energy expenditure.

Reports regarding effects of environmental temperature on energy requirements are equivocal. Swain et al. (1949) studied troops at Fort Churchill, North west territory, Canada for two successive winter and showed that there Calorie requirements were 5000 kcal/d. On the other hand, Acheson (1974) and Campbell (1975) reported an average daily intake in Antarctica was 3107 kcal/d in base and 2892 kcal/d in field area with a change of 1.98 kg in mean body weight, which was recovered on return to base. Recently King et al. (1993) reported an average intake of 3000 to 3700 kcal/d in troops living in Alaska in tents (Temp. -28 °C) during winter, whereas, the energy expenditure of a subgroup of these individual was 4253 kcal/d when measured by the Doubly Labelled Water technique.

In the present study energy intake is also similar to as reported by LeBlanc (1957) and is about 600 kcal/d more than reported by Rodahl (1954). In the study by Rodahl (1954) subjects had very low activity level whereas in the present study subjects had fairly high activity and average total energy expenditure was 3120 + 474 kcal/d. But there was a positive energy balance and a net result was the gain in body weight.

Increase in the body fat was observed during the study. Body fat changes for most of the subjects were similar to their body weight changes. Similar results were reported in some earlier studies. Majumdar et al. (1994), observed that mean body weight and mean skinfold thickness at eleven different sites of 18 men of the expeditioners were increased significantly throughout their 14 months stay at Antarctica. The maximum increase of mean body weight was 6.14 Kg in 14 months. In other study Satija et al. (1998) reported the average weight gain was 4.37 kg in control subjects resided in Antarctica for 60 days with a maximum of 5.87 Kg. Increase in body fat is also in correlation with earlier report of Satija et al. (1998). The body mass index (BMI) accounts for differences in body composition by defining the level of adiposity accounting to the relationship of weight to height. Since BMI directly correlates with body weight and body fat, BMI less than 25 is consider normal, 25 to 30 as overweight and greater than 30 as obese. The increase in BMI is due to the increase in body weight. However, BMI does not assess body composition per se. It only provides a basis for assessing the health risk associated with excess body fatness.

Animals living in extreme climatic conditions show a marked seasonal variation in both food intake and energy expenditure, as a response to the changing metabolic requirements imposed by differences in environmental temperature (Trayhurn and James, 1978; Trenkle, 1978). Energy intake and expenditure are under strict control by the product of the *ob* gene, leptin, an adipocyte-secreted hormone. Leptin acts on hypothalamic centres and regulates the energy balance by modulating both food intake and energy expenditure (Zhang et al., 1994; Ahima et al., 1996). Plasma leptin concentration reflects the adipose tissue deposits (Maffei et al., 1995; Havel et al., 1996). It appears to be negatively regulated by fasting, protein kinase androgenase and (3-andrenergic agonists (Ahima et al., 1996; Mantzoros et al., 1996; Pineiro, 1998), whereas feeding, oestrogens, glucocorticoids and insulin (De Vos et al., 1995; Ahima et al., 1996; Hardie et al. 1996; Casabiell et al., 1998) act by stimulating both *ob* gene expression and leptin secretion. Furthermore, leptin is indicator of physiological states that require variation in energy expenditure and energy intake like exercise (Leal-Cerro et al., 1998).

In the present study the decrease in leptin level after two days stay in Antarctica in comparison to the initial values, reflect the effect of cold exposure on human subjects. Though it was reported that circulatory leptin level is directly proportional to the body weight and fat mass (Halaas et al., 1995). However, in the present study a decrease in leptin level was observed in spite of increase in body weight and fat mass. The decrease in leptin level in this present study is in concordance with the previous study on animal (Trayhurn et al., 1995; Hardie et al., 1996) and human (Peino et al, 2000; Ricci et al., 2000). Ricci et al. (2000) demonstrated that women volunteers showed a 14, 17 and 22% decrease in plasma leptin level at 30, 60 and 90 min respectively, of cold (6.3 ± 0.5 °C) exposure. This cold-induced decrease in plasma leptin was not related to a decrease in plasma insulin, what we have observed in this study.

The decrease in leptin level with increase in fat after cold exposure may represent an adaptive mechanism for maximising the size of fat deposit when the environmental temperature begin to decline, in order to survive the cold season. As the adrenergic tone increases in vivo when the temperature is lowered, it is possible that an increased stimulation of the adipocyte specific |3$_3$-adrenergic receptors, with the ensuing increase of the intracellular c AMP levels, which would in turn inhibit the *ob* RNA expression, may constitute the physiological basis for this leptin reduction. It has been reported that this is the case for mice (Moinat et al., 1995) and rats (Trayhurn et al., 1995).

Thus, the decrease in leptin levels after induction to Antarctica in spite of increase in body fat mass may be the adaptive mechanism against cold stress. Increase in leptin levels after one-month stay in Antarctica shows the completion of acclimatisation process and the feed back mechanism of adipocytes to brain about the fat store.

Neuropeptide Y increase food intake following injection into the paraventricular, ventromedial, and other hypothalamic regions (Leibowitz, 1986). Chronic injections have been shown to produce obesity (Leibowitz, 1986). This would predict that NPY would reduce sympathetic firing rate. A mapping study showed that injection of NPY into the PVN increase food intake and reducing the firing rate in multi-unit recording from sympathetic nerves to BAT (Tsujii and Bray, 1989).

The massive increase in circulating NPY level in this study after two days of stay in Antarctica may be either due to decrease in circulating leptin levels or it may be the adaptive mechanism to thermogenesis in BAT. The sequence of events which result in BAT activation involve afferent thermal signals from the skin temperature-sensitive neurons within the hypothalamus, co-ordination within the hypothalamus, and activation of sympathetic out flow to the periphery (Himms-Hagen, 1984). McCarthy et al. (1993) showed a raised level of hypothalamic NPY in 18h cold-exposed rats. Exposure to cold also increased NPY concentrations in the paraventicular nucleus and ventromedial nucleus in lean rats, with no change in NPY messenger RNA after either 2.5 or 18h (Bing et al., 1997). Thus the increase in NPY level may be the adaptive mechanism to increase the food intake, decrease energy expenditure to survive in cold environment. Exogenous NPY administration consistently stimulates feeding especially carbohydrate intake, in vertebrate species (Leibowitz, 1995; Kalra, 1997; Heinrichs et al., 1998). Combined with a reduction in thermogenesis, NPY is considered to be of fundamental importance as a component of the hypothalamic control of appetite and body weight. Evidence supporting this implication comes from experiments showing that an increase in NPY secretion in the paraventricular nucleus at the beginning of the dark period is associated with food intake (Kalra, 1997; Stricker-Krongrad et al., 1997).

During acute cold exposure, metabolic rate increase through shivering to produce more heat and thus prevent central hypothermia. Carbohydrates and lipids play important role during cold exposure. Lipids and carbohydrate oxidation increases to maintain an increased metabolic rate in case of cold exposure (Vallerand et al. 1983; Vallerand and Jacob, 1989), and serve as a primary substrate for the shivering skeletal muscle. It has been reported that plasma free fatty acid oxidation and turnover, as well as peripheral glucose uptake and muscle glycogen utilisation, are all greatly enhanced in both cold exposed animals and humans (Martineau and Jacobs, 1988; Vallerand et al., 1988).

Numbers of studies suggested that acute prolonged exercise greatly enhances lipid metabolism through an increased utilisation of lipid from all the three fat stores. Exercise increases plasma glycerol levels (Newsholme and Leech, 1983), plasma free fatty acid turnover (Paul and Holmes, 1975), plasma triglyceride utilization (Annuzi et al., 1987; Lamon-Fava et al, 1989) and skeletal muscle lipoprotein lipase activity (Lithell et al., 1981) as well as intramolecular triglyceride utilization (Spriett et al., 1985). It is known that intramuscular triglyceride utilization and very low density lipoprotein turnover are both increased during shivering in rats (Therriault and Poe, 1965; Radomski and Orme, 1971) and that in dogs, plasma free fatty acid is thought to represent the major source of fatty acid for oxidation in the cold (Vincent-Falquet et al., 1972).

The significant increase in HDL-cholesterol with decrease in LDL cholesterol levels in the present study may be due to the consumption of seafood rich in o>3 fatty acids (Ulbricht and Southgate, 1991). Since a number of sea food items included in the menu of the expeditioners during the sea journey and it has been found that there is a positive correlation between the amount and type of fat consumed and the levels of the blood lipids; those consuming less saturated fat usually have low serum cholesterol levels. In the present study, no significant change in total serum cholesterol level was observed after the sea journey or after one-month stay in Antarctica.

It was observed that endurance athletes have elevated blood high-density lipoprotein concentration. Two mechanisms have been proposed to account for this elevated HDL concentrations. The HDL levels appear to vary inversely with the activity of hepatic triglyceride lipase (HTGLA) and this enzyme may play a role in HDL catabolism (Eisenberg, 1984; Sady et al., 1984). In contrast, HDL concentrations are positively related to the activities of lipoprotein lipase (LPLA) (Eisenberg, 1984; Sady et al., 1984), an enzyme thought to promote transfer of lipids to HDL from chylomicrons and very low-density lipoprotein. Post heparin plasma HTGLA is generally lower and LPLA higher in trained subjects than in sedentary individual (Herbert et al., 1984). Though in the present study LPLA and HTGLA were not studied but since the subjects had very active life style and consuming seafood containing co-3 fatty acids may be the reason for increased HDL cholesterol after reaching Antarctica and during stay in Antarctica.

It may be concluded that expeditioners have very active life style in Antarctica and the increase in body weight and body fat may be due to positive energy balance. The increase in food intake may be due to decrease in leptin and increase in neuropeptide Y levels and may be in response to cold and is a acclimatization process.

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