Some of the metabolic changes in expedition members caused by diet and activities performed during a stay at the Czech Antarctic base

Short Communication

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Abstract

The aim of this study was to evaluate the effect of food intake, extreme climatic and other environmental conditions on metabolic parameters in serum in participants of the 9th Czech Antarctic Scientific Expedition, January – February 2015 (8 weeks). The studied parameters included the level of total cholesterol, high-density lipoprotein (HDL) cholesterol, triglycerides, uric acid and type of diet. The energy intake, amount of protein in food during the stay were analysed. The values of the above-specified parameters were compared with the answers of respondents to questions about food intake served during the expedition and analysed by the (ANOVA) Hartley F, Cochran C, Barttlet Chi test. A total of 45 sera samples were collected during 3 series of sampling. The first one was a pre-departure sampling, the second was taken after the first 2 weeks of the stay in Antarctica, and the third one during the last 2 weeks of the stay). Statistically significant decrease in uric acid and HDL cholesterol in sera was observed during the stay. For this purpose, Student´s paired t-test was used. Scheffe test revealed significant differences in levels of HDL between categories of expeditioners who ate significantly larger amount of protein and equal amount of proteins after 44 days of expedition. In this paper, we discuss the total cholesterol (HDL, LDL), which can lead to dietary problems under stress condition in the Czech Antarctic base.

Key words: Antarctica, HDL cholesterol, uric acid, diet

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Introduction

It is well established that a diet rich in total fat, saturated fat and cholesterol is associated with an increased risk of coronary heart disease and is reflected in a higher serum level of LDL cholesterol and triglycerides. In contrast, diet with low saturated fat and high amount of monounsaturated fat can contribute to a low incidence of cardiovascular disease and is associated with a higher level of high density-lipoprotein (HDL) cholesterol.

The higher level of uric acid contributes to the faster progression of diabetic kidney disease and higher incidence of major cardiovascular event in type 2 diabetic patients. The increased intake of a diet rich in purines leads to the overproduction of uric acid. In contrast, the decrease in the serum level occurs under physical activity and in manually hard working subjects.

Extreme physical activity associated with staying in Antarctica put emphasis on diet so as to avoid adverse effects on health. The diet should contain different composition of macromolecules ensuring greater calorific intake and preventing weight loss. If the fat a protein reserves are depleted the body is forced to consume vital tissues and physiological functions and cardiovascular capacity are getting worse. Although exist many studies about Antarctic diet, there is no optimal ratio of dietary substrates for staying a working in extreme environment of Antarctic. Nevertheless, diet includes more fat and carbohydrate is probably best (Halsey et Stroud 2012, Stroud 1998).

Changes of several metabolic parameters in human blood levels during a stay in extreme conditions of Antarctica and the effect of extreme environment on the health of expeditioners is the subject of many studies. In the last decades, the numbers of tourists, industry employees and scientists visiting the extremely cold regions (particularly in the Arctic and Antarctic) have increased dramatically (Kaltenborn 2000). Moreover, novel sport events take place in the polar regions. Such increased human presence in polar regions also means a higher risk of incidence of health problems (Brat et al. 2014). Thanks to a geographical isolation of Antarctic, polar expeditions members represent an opportunity to study chosen parameters without the effect of civilisation. On the other hand, it must be taken into account that psychological and physiological stress which may be associated with isolation can significantly influence results. Therefore, it is important to study the principles of adaptation of human body to the extreme conditions of these environments, especially in the area of metabolic changes. The 9th Czech Antarctic Scientific Expedition (held between December 2014 and February 2015) created suitable environment for monitoring food intake. In this study, we report the summer short-term effects on the serum lipoproteins related to the higher intake of protein.

Material and Methods

Background

J. G. Mendel research base is a summer-operated station located on James Ross Island, east of the Antarctic Peninsula. Coordinates of the station are 63° 48' S, 57° 53' W. The building of the station is located at altitude 9 m a.s.l. Main scientific activities performed during each summer season comprise the research on climate change, and the following disciplines: glaciology, geology, biology of lower plants, microbiology, chemistry and others.

Subjects

All study subject belonged to the 9th Czech Antarctic Scientific Expedition consisted of fifteen subjects (volunteers) participated, of these 3 women and 12 men (Žákovská et al. 2015). All participants were of European origin, age ranged between 25 and 61 years (mean 37.9 years, median 35 years). All expeditioners were weighed and registered for blood pressure at the beginning and end of the study, (*see* paragraph of laboratory analyses). Body mass index (BMI) was calculated, mean 25.36 (± 3.55). The participants were healthy, none of the subjects was treated for any kind of disease. During the stay in Antarctica, the scientists worked several hours a day in the field, covering daily walks ranging 10-15 km in average. Exceptionally, they had some 30-35 km long walks in a day to distant areas from J. G. Mendel station.

Laboratory analyses

The procedures of pre- and post-race blood sampling were identical Blood was collected from an antecubital vein from 15 subjects using one S-Monovette tube (plasma gel, 7.5 ml) (Sarstedt, Praha, Czech Republic) for chemical analysis. The first was taken before the expedition members left the Czech Republic (December 23rd – 29th, 2014), the second during the first month of the Antarctic stay on January 20th, 2015, and the third before the end of the expedition on February 10th, 2015. A total of 45 sera samples was collected in 3 series, the sera were separated and frozen at -20°C. The value of total and HDL cholesterol, triglycerides, uric acid was gained turbidimetrically by an ELISA reader – Rainbow (SLT Instruments) using reagent sets (BioSystems S.A.). All participants were divided into categories based on subgroups derived from the dietary questionnaire analysis.

Statistical analyses

Changes in values of HDL, total cholesterol, triglycerides, urine acid in dependence on the intake of lipoprotein during the summer Antarctic expedition were analysed by a single repeated measures analysis of variance (ANOVA) Hartley F, Cochran C, Barttlet Chi test. Normal residuals were evaluated by a graph of the normal distribution. Statistical significance of the mean HDL values of the group was evaluated by Scheffe test. Ttotal cholesterol, triglycerides, urine acid were not statistically significant. Changes in HDL cholesterol, uric acid, triglycerides, total cholesterol, BMI, weight, energy and meat intake between pre-departure values and values measured on January 20th, 2015 and those measured on February 10th, 2015 were analysed by Student's paired t-test ($p < 0.05$). Statistics were performed by using statistical software STATISTICA 12 (StatSoft Inc, USA). Results are expressed as the mean ± SD.

Results

We have found statistically significant differences in the values of HDL cholesterol and uric acid (Table 1). The decrease in uric acid in serum was observed as early as at the second sampling ($p < 0.0009$). Further decrease in uric acid was detected at the end of the expedition (when compared to the pre-departure values) ($p < 0.01$), (Table 1). Statistically significant decrease of HDL cholesterol in serum was observed in samplings be taken on February 10th, 2015 when compared to the pre-departure values ($p < 0.01$), (Fig. 1, Table 1). Scheffe test revealed significant differences in HDL after 44 days of expedition in expeditioners who were divided into two categories: these who ate significantly larger amount of proteins and those with equal amount of protein during 44 days of expedition. The value of HDL concentration in person eating more protein was significantly lower (Fig. 2). Statistically significant differences were, however, not observed in values of total cholesterol, triglycerides, BMI, weight, energy and meat intake (Table 1). The values of dietary variables are summarized and presented in Table 2.

Variable	Control period	Expedition period 1	Expedition period 2
Total cholesterol (mmol/L)	2.58 (± 1.98)	2.75 (± 2.24)	4.67 (± 4.46)
HDL cholesterol (mmol/L)	1.24 (± 0.63)	1.36 (± 0.64)	0.79 (± 0.42)[1]
Triglycerides (mmol/L)	5.17 (± 2.65)	6.59 (± 2.94)	5.49 (± 4.00)
Uric acid (µmol/L)	284.28 (± 133.69)	262.66 (±77.89)	207.76 (± 52.97)[2;3]
Body weight (kg)	81.26 (± 15.19)	-	81.4 (± 14.09)
BMI	25.36 (± 3.55)		25.43 (± 3.27)

[1] Significantly different from expedition period 1 ($p < 0.01$; Student's t-test)
[2] Significantly different from expedition period 1 ($p < 0.0009$; Student's t-test)
[3] Significantly different from control period ($p < 0.01$; Student's t-test)

Table 1. Represents an overview of lipid concetrations, body weight and BMI in 15 subjects during the summer Antarctic expedition. Values are presented as means ± SD.

Dietary variables (mean)	Expedition period 1 (after 23 days of expedition)	Expedition period 2 (after 44 days of expedition)
Energy (Kcal)	2 496.56 (± 339.02)	2 487.84 (± 186.06)
Protein (% of energy)	31.67 (± 7.10)	30.08 (± 8.39)
Protein (g)	330.24 (± 212.64)	403.6 (± 212.64)

Table 2. Represents dietary data in both parts of expedition duration, (values were without statistical difference, $p > 0.05$, Student's t-test).

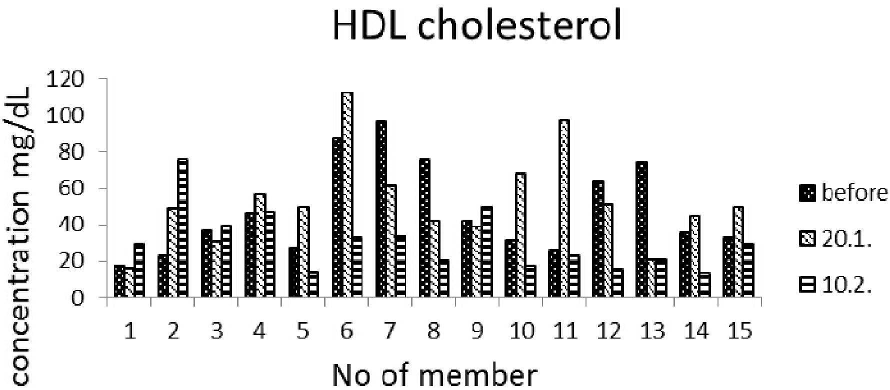

Fig. 1. Represents the measured changes in HDL cholesterol values in serum of each subject. ***x-axis***: number of subjects, ***y-axis***: concentration of HDL mg/dL

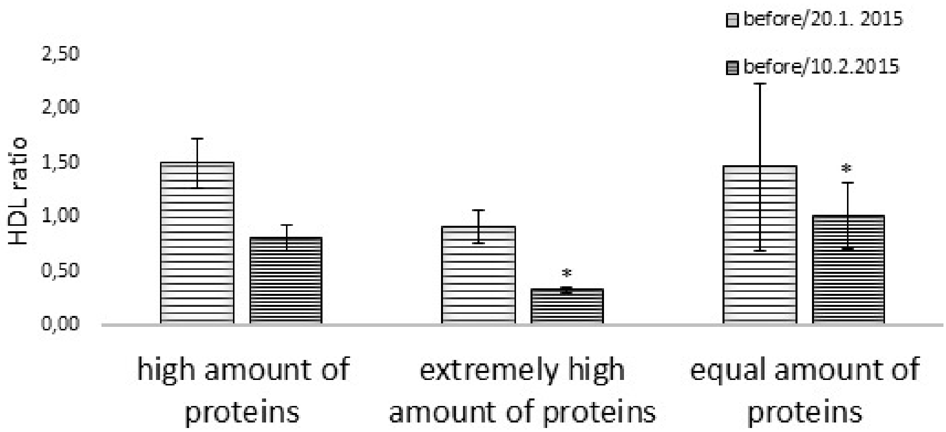

Fig. 2. Statistical dependence HDL cholesterol levels on the intake of meat. ***x-axis***: distribution of expeditioners by answering the question, ***y-axis***: the ratio of value of HDL in the date of collection to intake of proteins

Discussion

A high consumption of energy-rich food is responsible for the development of obesity and cardiovascular disease. That is why a lot of studies were devoted to dietary problems. For example one of them investigated the gut functions and serum lipids profile of high-fat diet compared to the type of fat in rats (Jurgoński et al. 2014). Other studies focused on fatty effect on human serum lipoprotein profile (Mensink et Katan 1990, Jones et al. 1994). Not many studies, however, exist about diet research in extreme environments such as Antarctica. Panin (2007) defines a polar metabolic type that is formed in the Arctic and Antarctic regions. The most pronounced alterations associated with this type is energy metabolism (Panin 2007). The analysis of metabolical changes and their influence on lipid profile and anthropometric variables of participants in the Antarctic environment was undertaken in the study of Fernándes - Riestra et al. (2006). Their research showed that not only diet and food intake can lead to the change in metabolic variables. They find that people working in Antarctica are exposed to a very cold environment, seasonal and photoperiodic changes, low relative humidity, high electromagnetic radiation and social, communicative and geographic isolation (Fernándes - Riestra et al. 2006). Psychological changes resulting from the exposure to a long period of isolation and extreme physical environment are described and identified as the possibly interacting factors casing metabolic changes in polar expedition members (Palinkas et Suedfeld 2008). To study factors controlling serum cholesterol level, the effect of higher lipoprotein intake on cholesterol level was examined in this study from polar environment. There is still a considerable difference of opinion as to what constitutes the suitable polar diet. The mean energy intake of our polar expedition diet was 2 496.56 (± 339.02) kcal in the half of stay and 2 487.84 (± 186.06) at the end, which exceeds the average recommended intake per day. For a 23-50 year old woman, the reference level intake is about 1 800 kcal and 2 300 kcal for men (Food and nutrition information center [1]; Husák 1994). Moreover, the share of energy of protein to total energy intake reached 31.67 (± 7.10) %, which is 330.24 (± 212.64) g in the half of the expedition season. At the end of the expedition, the share was 30.08 (± 8.39) %, which is 403.6 (± 212.64) g. Such protein intake was marked by the majority of respondents in the questionnaire as high or extremely high. Only four of them described the same meat intake as they have in the home condition. Scheffe test revealed significant differences in HDL levels between categories of expeditioners who ate significantly larger amount of proteins and equal amount of proteins after 44 days of expedition. The value of HDL concentration of persons eating more protein was significantly lower. Uric acid is an indicator of a higher increase of energy intake and meat. Although the food energy intake was higher than recommended and the HDL level of HDL cholesterol was decreased, the level of uric acid was in the middle of the stay and at the end statistically reduced. The increased intake of the diet rich in purines should lead to the overproduction of uric acid. Such uric acid reduction could be caused by increased physical activity and exercise of polar expedition members in extreme environments. To be in an environment with a relative lack of pathogenic microorganisms and pollutants can also play in decrease of uric acid. This opinion is supported by the similar conclusion of Fernándes - Riestra et al. (2006).

The nature of the consumed proteins contributed to the reduction in the HDL value of cholesterol. Most of the food included pork and beef. Poultry was prepared in small quantities and no fish was consumed. When compare to the study of Matheson et al. (1996), the participants in their expedition had a special diet with an emphasis given to various types of lipids. They showed the effect of separated using of a monounsaturated cooking oil on the lipoprotein and lipid profile in subjects during overwintering in Antarctica. After 13 weeks of such a diet they found a 6.7% decrease in total cholesterol and 10.0% decrease in LDL cholesterol (Matheson et al. 1996).

In contrast to several studies describing changes of BMI during stay in Antarctica, in our study we didn't find statistically significant change. The studies show inverse correlation between lower BMI and higher level of 5-OH vitamin D in serum (Valtuena et al. 2013, Rodriguez-Rodriguez 2009). Another study describes decrease BMI and decrease 5-OH vitamin D in serum (Steinach et al. 2015).

Conclusion

During the preliminary study, we analysed the effects of diet of an Antarctic expedition members on serum lipids. We found significant changes (decreases) of HDL cholesterol influenced by the food intake (high value of lipoproteins). In the case of uric acid, as an indicator of kidney disease, an increase in levels under the influence of the high intake of lipoproteins was expected. Despite our expectations, level of uric acid was significantly decrease. Our results may indicate that not only diet, but also the environmental influences (extreme conditions) and physical activity of monitored persons can influence the metabolic parameters.

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