CZECH POLAR REPORTS 9 (1): 107-113, 2019

Changes in haematological parameters during a summer expedition in Antarctica

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Abstract

The aim of this study was to examine the effect of extreme climatic conditions and a long stay in isolation on levels of three haematological parameters in the polar expedition participants. This article describes changes in erythrocyte count, hemoglobin and transferrin levels measured on the 9^{th} Czech Antarctic Scientific Expedition during the period of the Antarctic summer. A total of 15 sera samples were collected shortly before the expedition, the second sampling was performed halfway through the stay and the third at the very end of the expedition stationed at the Czech Research Station of J. G. Mendel. The erythrocyte count and the levels of transferrin were significantly increased in between all three sample collections (with p-value < 0.01). A statistically significant increase in hemoglobin levels was only detected between the first and the final sampling ($p <0.01$). We found that demanding physical performance, extreme climatic conditions and also the participants' lifestyle at the station had a positive, up-regulating effect on levels of the studied haematological parameters.

Key words: Antarctica, extreme environment, haematological parameters

DOI: 10.5817/CPR2019-1-9

Introduction

Antarctica is a continent with the most extreme climatic conditions, which can induce both positive and negative effects on the individual's health. Most of the negative effects on the researchers' bodies, such as low temperatures and stress from a long winter period, after spending months in extreme conditions and isolation, have been previously described (Turner et al. 2009, Muller et al. 1995). Our intention was to find out whether a long-term exposure during the summer period of the Antarctic year at the Czech Polar Station will affect human haematological parameters.

Red blood cell (RBC) count, hemoglobin and transferrin levels belong among biomarkers for the determination of anemia and other clinical conditions (*see* e.g. Northrop-Clewes and Thurnham 2013). RBC is an effective bioindicator of cardiovascular

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Received March 7, 2019, *accepted* April 30, 2019.
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Acknowledgements: The study reported in this paper was supported by the Specific Research Program at Masaryk University. The authors thank Czech Polar infrastructure (LM2015078, LM2010009).

diseases (Lassale et al. 2018), especially in smokers (Nordskog et al. 2015, Metta et al. 2015).

Red blood cells are the most common blood cell type and the vertebrate's principal means of delivering oxygen (O_2) to all body tissues – via blood flow through the circulatory system. The cell membrane is composed of proteins and lipids, and this structure provides properties essential for physiological cell function such as deformability and stability while traversing the circulatory system and specifically the capillary network (Kumar at al. 2007).

Hemoglobin is an important colour component of red blood cells. Hemoglobin and hemoglobin-like molecules are found in vertebrates mainly, in many invertebrates, fungi, and plants (Weber and Vinogradov 2001). In these organisms, hemoglobins may carry oxygen, or they may act to transport and regulate other small molecules and ions such as carbon dioxide, nitric oxide, hydrogen sulfide and sulfide (Weber and Vinogradov 2001).

Transferrins are iron-binding blood plasma glycoproteins that control the level of free iron (Fe) in biological fluids (Crichton and Charloteaux-Wauters 1987).

The World Health Organization (WHO) estimates that 1.62 billion people of the global population, are affected by anemia. Although anemia affects all age groups across all the world's populations, certain groups are more vulnerable than others. The highest prevalence tends to be in preschool-age children (*i.e.*, those aged 6–59 months), women of reproductive age (*i.e.*, those aged 15–49 years) and pregnant women (Northrop-Clewes and Thurnham 2013).

Low RBC count, amount of hemoglobin and transferrin could lead to syndromes such as fatigue, shortness of breath, dizziness and weakness. Reducing the number of red blood cells occurs for various reasons, whether it is an iron deficiency anemia with insufficient iron intake, blood loss, iron deficiency, a lack of minerals and vitamins but also ongoing inflammation (Straat et al. 2012). We aimed to identify whether there is an increase or decrease in basic haematological parameters under the influence of the unusual Antarctic environment.

Material and Methods

Background

Mendel Research Station is an Antarctic station operated during the summer periods by Masaryk University, the Czech Republic. The station is situated on the northern coast of James Ross Island in Antarctica; station coordinates: 63°48'05.06"S, 57°53'09.07" W at an altitude of 9 meters above the sea level. (Brat et al. 2016, Prošek 2013). The scientific research programme is mainly focused on climatology, geology, paleontology, glaciology, biology of lower plants, microbiology and other areas as well. The 9th Czech Antarctic Scientific Expedition took place from December 2014 until February 2015. Twelve scientists and 3 support members of the personnel participated in the expedition. The outside air temperatures (AT) on James Ross Island during the stay were: AT_{max} 9.3°C, AT_{min} -4.4°C and AT_{mean} 0.8°C (Kavan et al. 2017).

Subjects

Fifteen healthy subjects – participants of the 9th Czech Antarctic Scientific Expedition – were included (3 women and 12 men). The participants' age ranged between

25 and 61 years (mean 37.9 years, median 35 years), mean Body Mass Index (BMI) was 25.36 (± 3.55). All the subjects were healthy and none took any prescribed medication. For most of the expeditioners, the daily program usually included several hours of field work along with several hours of laboratory work.

Laboratory analyses

The blood sampling procedure was identical for each sample collection. Blood samples were collected at 3 time-points from the antecubital vein using one S-Monovette tube (plasma gel, 7.5 ml; Sarstedt, Prague, Czech Republic). The first collection took place in the Czech Republic between December 23rd and 29th in 2014 (pre-departure lot), the second lot was obtained during the first month of the expedition (January 20th, 2015) and the third collection took place at the end of the stay (February 10th, 2015). Of the 15 collected samples, the blood was immediately assessed (RBC count and protein concentrations) or stored in a refrigerator, sera were separated and frozen at -20°C, as partially described by Žákovská and Zezulová (2016).

The erythrocytes were evaluated using the Bürker chamber. Serum levels of transferrin protein were assessed using reagent set (BioSystems S.A., Barcelona, Spain) and measured by ELISA reader (turbidimetric method) Rainbow (SLT Instruments, Oxford, UK). The blood samples collected in Antarctica were analyzed directly in a laboratory at Mendel Research Station.

Research within the project proceeded in accordance with the law (No. 96/2001 Coll. M. S. on Human Rights and Biomedicine and Act No. 101/2000 Coll. Privacy).

Ethical approval

Ethical approval for the study was obtained from the Ethical committee of the Faculty of Science, Masaryk University, Czech Republic and Ethical committee of University Hospital Brno, Czech Republic. Written informed consent was obtained from each studied subject.

Statistical analyses

For each parameter, mean values, their standard deviations (SD) and medians were calculated. Paired t-test was used to compare data from the Czech Republic and from Antarctica. Results were statistically significant if p-value was lower than 0.05.

Results

The RBC count and the amount of transferrin were significantly increased in samples collected at each time-point ($p < 0.01$). The amount of hemoglobin was significantly increased only when the measured concentrations from the first and final sampling were compared ($p < 0.01$).

1. Changes (CH 1) between the first and second sample collection (20.1.).

Statistically significant changes were recorded in the RBC count, transferrin ($p < 0.05$) and hemoglobin ($p < 0.01$) levels (Table 1, Fig. 1).

2. Changes (CH 2) between the second (20.1.) and final sample collection (10.2.).

Statistically significant changes were recorded in the RBC count ($p < 0.05$) and the levels of transferrin ($p < 0.01$) (Table 1, Fig. 1).

3. Changes (CH 3) between the first and final sample collection (10.2.).

Statistically significant changes were recorded in the RBC count as well as transferrin and hemoglobin concentrations ($p < 0.01$) (Table 1, Fig. 1).

Body Mass Index (BMI) values of the participants were not significantly altered at the end of the stay with a mean value of 25.43 (± 3.27).

Parameter	Pre-expedition	CH 1	20.1.	CH 2	10. 2.	CH 3
Red blood cells [$10^{12}.L^{-1}$]	**4.52** ±*0.88*	*	**5.37** ±*0.74*	*	**6.09** ±*0.72*	**
Transferrin [$g.L^{-1}$]	**2.82** ±*0.72*	*	**3.79** ±*1.48*	**	**5.75** ±*1.69*	**
Hemoglobin [OD]	**0.14** ±*0.02*	**	**0.16** ±*0.01*		**0.17** ±*0.01*	**

Table 1. Comparison of immunological parameters in samples collected before the expedition, on the 20.1. and at the end on the 10.2. (Mean ± *STD*). CH 1: Change from the start until the 20.1.; CH 2: Change from the 20.1. until the 10.2.; CH 3: Change from the start until the 10.2. *Notes*: *p<0.05; **p<0.01, OD - optical density.

Discussion

Two months in extreme conditions is a relatively long period of time for blood parameters to change. The ability to adapt to extreme conditions such as a stay in a cooler climate results in physiological changes, which are necessary to regulate various stress factors (Morris et al. 2017).

Other factors that probably influence blood parameters are isolation from civilization, reduced prevalence of pathogenic microorganisms, reduction of stress associated with modern lifestyle, concentration only on selected tasks. All these aspects are likely to affect 15 expedition members during their 2–month stay at the Czech Research Station.

These factors, which have been affecting humans for a while, have led us to try to capture possible changes in human physiology.

The aim of our research was to find out whether the three main blood parameters of the 2015 polar expedition at the Research Station will change and how much.

It turned out that the amount of red blood cells before the expedition in six men did not reach the normal physiological value, whereas no deviations were observed in women. At the second measurement, halfway through the stay, all participants showed normal physiological values. At the end of the stay in Antarctica, five men and two women had exceeded the number of erythrocytes beyond the normal physiological value.

For hemoglobin only, an absolute value of a change was measured. The amount of transferrin was normal before the expedition, but the level increased beyond the physiological value after the Antarctic stay.

Several studies of immune changes in humans during long-term isolation have been performed (Francis et al. 2002, Gleeson et al. 2000).

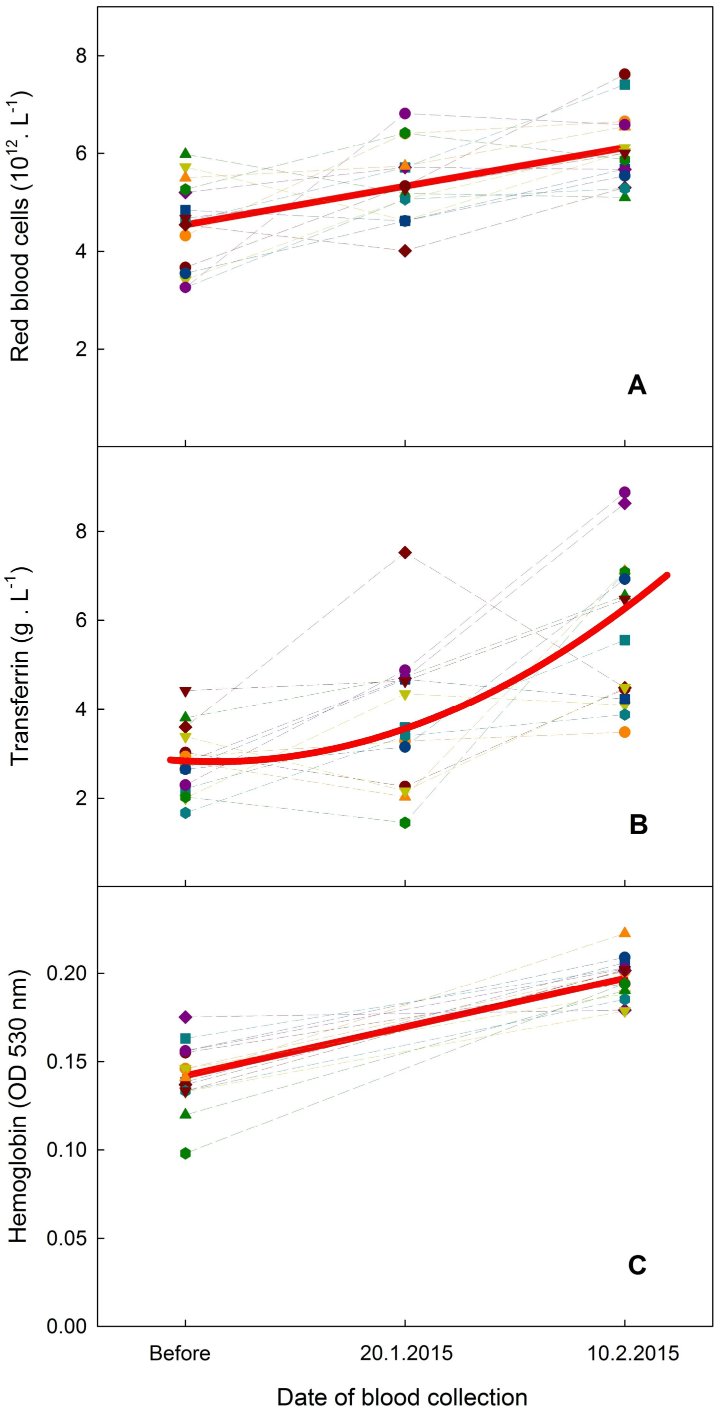

Fig. 1. Comparison of the haematological parameters evaluated before (20. 1.) and after (10. 2. 2015) the antarctic expedition. Best fit (lines/curve) is indicated by red line/curve.

For example, immunological research in Antarctica was focused on reactivation of latent viral infections during periods of long-term isolation. In most of the studies, increased frequency of herpesviral and Epstein-Barr viral infections have been observed after long-term residency in Antartica (Muller et al. 1995, Tingate et al. 1997).

Most of these studies took part in Antarctica and on the International Space Station. These studies revealed that during long-term stays in isolation and in extreme environmental conditions, multiple changes in the physiological system may develop. Some changes were observed also during short-term stays in the polar regions.

Most of these studies, however, were carried out on members of winter stays. Our group lived on the island of James Ross for only two months in the summer when the temperature did not fall below -20°C. We assume that frequent, even daily, physical activity in remote areas with cold environments, long-term exposure to daylight, which was not used and higher intensity of sunlight could affect the activity of red blood cells and rapidly increase their number along with the amount of transferrin and hemoglobin. Another reason for a significant change in RBC count could be the meal pattern and total nutritional intake during the stay. Participants reported in the questionnaire that 80% took more supplements and 73% consumed more meat; 60% drank less fluids; 86% consumed less vegetable; only 20% took in more sugar in Antarctica than at home, in the Czech Republic. A person with reduced levels of hemoglobin may benefit from eating more iron-rich foods, which is likely to induce an increase in levels of hemoglobin and transferrin as well as number of red blood cells. Iron works to boost the production of hemoglobin, which also helps to form more red blood cells (Kumar et al. 2007).

Conclusion

We have found a statistically significant increase in all tested haematological parameters. We conclude that the health status of the expedition participants improved after two months spent at the Czech Research Station.

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