Life Sciences in Space Research 4 (2015) 17–21

Contents lists available at ScienceDirect

Life Sciences in Space Research

www.elsevier.com/locate/lssr

Magnetic storms and variations in hormone levels among residents of North Polar area – Svalbard

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ARTICLE INFO

Article history:
Received 7 October 2014
Received in revised form 11 December 2014
Accepted 15 December 2014

Keywords:
Geomagnetic activity
Hormone secretion
North-Polar area
Atmospheric pressure

ABSTRACT

In the present work four examinations (January, March, June, October 1991–1992) of the blood concentration of adrenal hormones (cortisol) and thyroid hormones (triiodothyronine (T3) and thyroxine T4) and their dependence on space and terrestrial weather parameters have been done for large groups of healthy inhabitants of high latitudes (Svalbard, the most northerly in the world year-round inhabited settlements). The aim of this study was to find the possible sensitivity of these biochemical parameters to variations of external natural factors at high latitudes in three independent groups of people living in this region (miners and people working underground (364 samples), the men working on the ground (274 samples) and women working on the ground (280 samples)).

The obtained data indicate that the most expressed dependence of concentration of the three studied hormones is on the level of geomagnetic activity (GMA) – Kp, Ap, Kpmax – 3h. For two of the four seasons (June and October) with increasing levels of GMA a significant ($p < 0.05$) increase in cortisol concentration in all three independent groups of people was observed. Range of increases in cortisol concentration in different groups were about 30% of the observed variation in the average intragroup concentration in June and from 16% to 38% in October. For T3 dependence was found only in June: drop in hormone secretion with increasing levels of GMA from 18 to 30% of the average range of intragroup variations.

Thus it was shown for the first time that at high geographical latitudes with increased level of GMA a significant change in the level of secretion of several hormones leads to the type of adaptive stress reaction.

1. Introduction

It was previously shown that magnetic storms lead to an increase in the level of cortisol and other stress hormones (like noradrenalin) in healthy and sick people with cardiovascular diseases (see Fig. 1 from Rapoport et al., 1995; Breus and Rapoport, 2003). However, in the healthy group in the cited study there were only 4 people and it seems that these results need to be checked.

It is known that cortisol increase in stress situations is leading to an increase in blood glucose levels and is providing energy to cells of the central nervous system. Thus, an increase in cortisol synthesis is one of the elements of the adaptive response of the organism to an external stress.

Thyroid hormones – triiodothyronine T3 and thyroxine T4 – are involved in the regulation of many processes in the organism, including their influence on the heart rate, blood pressure, motor and mental activity.

Thus, changes in concentrations of aforementioned hormones might be one of the possible mechanisms accounting for the effect of the blood pressure increases in healthy individuals and patients with cardiovascular disease under the effect of magnetic storms (Breus and Rapoport, 2003).

Actually the above-mentioned research has been the only one which examined stress hormone level changes with increasing levels of geomagnetic activity (GMA). We should also mention that it was conducted in the mid-latitudes (Moscow, 55°45N/37°36E). However, with increasing geographical latitude oscillation amplitude of the geomagnetic field during magnetic storms increases dramatically. Thus, the question is to which extent the endocrine system of healthy people residing in severe conditions of the

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http://dx.doi.org/10.1016/j.lssr.2014.12.001
2214-5524/

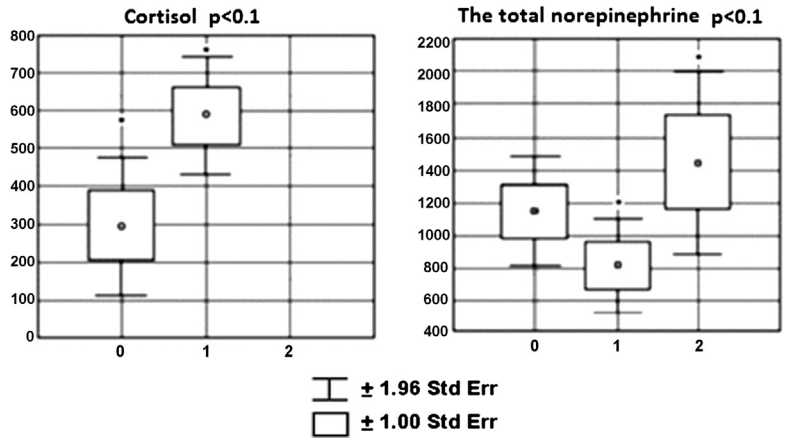

Fig. 1. The cortisol (left) and total norepinephrine (right) in the urine of patients with ischemic heart disease and hypertensive disease during geomagnetically quiet conditions (0), during disturbed conditions (1) and during geomagnetic storms (2) (Breus and Rapoport, 2003).

Table 1
The number of measurements in each sample (seasonal and groups).

Seasons	Start of measurements	End of measurements	Group 1	Group 2	Group 3
March	16.03.1991	25.03.1991	100	94	82
June	08.06.1991	25.03.1991	86	66	70
October	05.10.1991	19.10.1991	82	57	74
January	19.01.1992	03.02.1992	96	57	54

northern territories and exposed disturbances of the GMA, becomes relevant?

The aim of these studies was to examine the possible sensitivity of these biochemical parameters to variations of external natural factors at high latitudes.

2. Materials and methods

The four series of measurements of hormone concentration in the blood of healthy residents of the most northerly in the world year-round inhabited settlements (Svalbard, Barentsburg 78°04′N, and 14°13′E) in January, March, June and October 1991–1992 were conducted in this studies.

Three independent groups of people living in this region were examined:

- The man working underground – miners (364 samples) (Group 1)
- the men working on the ground (274 samples) (Group 2)
- the women working on the ground (280 samples) (Group 3)

The concentrations of adrenal hormones (cortisol) and thyroid hormones (triiodothyronine (T3) and thyroxine T4) in venous blood serum were investigated.

The number of measurements in each sample (seasonal and groups) are shown in Table 1.

Blood samples were collected from 6.01 to 10.59 of Moscow time (volunteers lived and worked using the Moscow time in Svalbard). These time period of examination was selected because there is a morning peak of cortisol according to international standards coinciding with a common practice tied to the way of people live.

At Svalbard mines miners are working according to two-year contracts. For this reason, only 27 people were able to be investigated in all 4 seasons, while remaining groups were chosen randomly assigned. Duration of examinations in the season was about 7–8 working days in the first days of each month when the study has been done.

For the analysis we used the following parameters of space and terrestrial weather:

- index of intensity of solar radio emission at the wavelength 10.7 sm (RF10.7),
- planetary geomagnetic activity indexes – the daily Kp-index (Kp), the daily average Ap index (Ap), the maximum per every 3-hour Kp-index (ftp://ftp.ngdc.noaa.gov/STP/GEOMAGNETIC_DATA/INDICES/KP_AP),

as well as the

- daily average indicators of flux rate of galactic cosmic rays neutron component (N),
- atmospheric pressure (P_{atm}),
- its rate of change (the difference between the P_{atm} today and yesterday) according to the geophysical station Oulu (Finland, http://cosmicrays.oulu.fi/).

2.1. Methods of analysis

Calculations were made in the software environment MATLAB R2010a by built-in functions. 12 independent sampling distributions corresponding to the three cohorts of subjects for 4 seasons (Table 1) were analyzed by two statistical methods.

2.1.1. Correlation analysis

Each measured physiological parameter within each of the sampling distribution was mapped to the values listed above indicators of space and terrestrial weather on the day of measurement, as well as a day before and two days after this blood sampling.

Since the majority of the studied sample distributions did not satisfy the criteria of normality according to the Jarque–Bera test, the Spearman rank correlation coefficient (r_s) with the assessment of the significance level (p) was calculated. Then module of maximum of correlation coefficient within the range of these shifts was selected.

For convenience of presenting the results for each pair of values of r_s and p a combined ratio $K_s = -\text{sign}(r_s) * \lg(p)$ was calculated (Fig. 2).