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COMPARISON OF CHANGES IN THE HUMAN CARDIOGRAM DURING SPORADIC AND RECURRENT GEOMAGNETIC STORMS (ON THE EXAMPLE OF THE INHABITANTS OF YAKUTSK CITY)

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The analysis of changes of a symmetry coefficient of a T-wave of the electrocardiogram during two types of geomagnetic storms is carried out. It is shown that the growth of the parameter characterizing a state of a human cardiovascular system coincides with the beginning of a storm. Maximum values are reached on the third day after the beginning of a storm – at the recovery phase. More clearly this dependence may be observed for the recurrent storms.

Key words: geomagnetic storm, cardiovascular system, human health, Dst-index

Introduction

At the present time a dependence of human health on solar and magnetic storms can be considered as an established fact. In this regard, there was even the term "space weather" because studies show that the magnetic field of the Earth has at times no less, and even greater impact on people's health and in general on living organisms, than meteorological factors and terrestrial weather.

Recent research established [1-5] that main target, which is influenced by heliogeomagnetic disturbances, is the heart and cardiovascular system. It is shown in such indicators, as a variability of a heart rhythm and frequency of heart reductions. In [3] it is shown that one can identify the disease, essentially determined by external (ecological) factors (exogenous nature of the disease or

factors related to the characteristics of the functioning of the body's own (endogenous nature of the disease). The former include cardiovascular disease (cerebrovasculitises, heart rhythm disorders, ischemic heart disease), and upper respiratory tract infection (bronchitis, asthma, etc.).

Nevertheless it is noted [2], despite the undoubted successes of the cardiology which has revealed of multiple risk factors for cardiovascular diseases, it is still unclear what exactly is the reason for starting of sharply developing coronary insufficiency, and what role of external factors is.

The aim of our work is to clarify the dependence of the cardio-vascular system of the geomagnetic conditions (from magnetic storms) on the example of inhabitants of Yakutsk city.

Geomagnetic situation

The comparison of changes of the parameter characterizing a cardiovascular system state (of a symmetry coefficient of a T-wave of the electrocardiogram) at group of volunteers in Yakutsk, with geomagnetic storms within March and April, 2011 is carried out in this work.

For this period 8 geomagnetic storms were recorded. The parameters characterizing storms are specified in table 1: data, storm beginning hour(Δt), storm main phase duration, low-latitude Dst-index amplitude(ΔDst), class of a storm, high-latitude AE-index sum (ΣAE), parameter β and type of a storm – sporadic (s) or recurrent (r). The class of a storm was determined by Dst-index amplitude – a difference between the maximum value of an index and the minimum in the main phase of a storm. According to [6, 7], there are 5 classes of a storm basing on the Dst-index decreases: small storms with Dst amplitudes from 31 to 50 nT, moderate storms – from 51 to 100 nT, big storms – from 101 to 200 nT, and storms with amplitudes more then 200 nT usually named extra- or superstorms. During period under the consideration there were registered 4 moderate (M) and 4 small (S) storms.

Table 1. Data and parameters of the geomagnetic storms durin March-April of 2011.

№	Date	Begino	Δ t	Δ Dst	Class	Σ AE	β	Type
1	March, 1	10	6	84	M	3358	0,0250	s
2	Marcy, 10	01	31	84	M	15153	0,0055	r
3	April, 1	17	11	52	S	5191	0,0099	r
4	April, 6	10	11	67	M	8022	0,0084	r
5	April, 8	15	13	40	S	4436	0,0090	r
6	April, 11	17	18	79	M	3930	0,0201	s
7	April, 18	8	10	43	S	2917	0,0147	s
8	April, 19	23	11	42	S	3313	0,0127	s

Dst- and AE - indexes of a geomagnetic field during March-April, 2011 are shown in fig.1. The left axis – Dst in nT (the top curve), the right one – AE in nT (the bottom curve), on the x axis – days of months. These indexes show the geomagnetic field activity at low (Dst) and high (AE)

latitudes. The first one characterizes the intensity of the ring current located in an internal magnetosphere with the radius about 6 Earth's radiuses, and the second one caused by ionospheric current systems in polar and subpolar regions of the Earth.

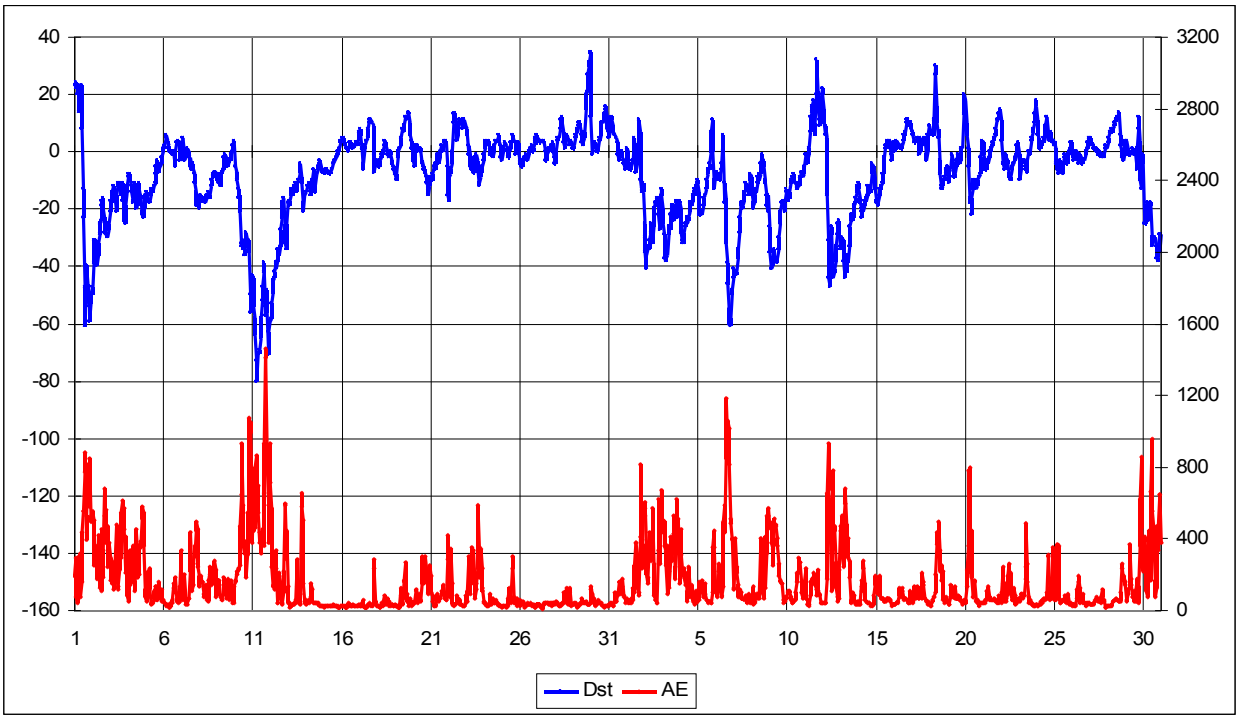

Fig. 1. Geomagnetic storm indices Dst (top curve, left scale) and AE (bottom curve, right scale) at March-April of 2011.

Geomagnetic storms can be refer according to their origin in two types [6]. Sporadic storms are caused by solar wind flare streams, and the recurrent one are usually caused by long-living high-speed streams. It was suggested in [8] for the storm type definition to use a parameter β which is calculated on a formula:

$$\beta = \Sigma \, AE / \Delta \, Dst,$$

where Σ AE is the sum of AE-index during the main phase of a storm Δt, and Δ Dst is amplitude of Dst-index. This suggestion is substantiated by understanding that these two indexes characterize the energy entering from the interplanetary medium into the magnetospheres during the storm main phase: Σ AE – to the auroral region, and ΔDst to the equatorial region (ring current). It is shown [6] that for the two types of the storms parameter β significantly differs. Sporadic storms (flare type) have β <0,0100, and for recurrent storms β> 0,0120. Thus, using β one can to determine the storm type – sporadic (s) or recurrent (r). The calculated values Σ AE and β, and also type of a storm are shown at three last columns of Table 1.

At the analyzed time interval four storms are carried out to a moderate (M), and another four

storms – to the small (S) according to common opinions (Tabl. 1). Two moderate storms were sporadic type (No. 1 and No. 6), and two – recurrent type (No. 2 and No. 4). Small storms also were divided: two recurrent types (No. 3 and No. 5) and two sporadic one (No. 7 and No. 8). It is necessary to note that two moderate storms, sporadic (first) and recurrent (second) may be considered as isolated: the second storm began 5 days later after the end of the first one. The end of a storm is time, then Dst-index returned to it prestorm level (see fig. 1). Four storms at the first half of April followed one after another with an interval of 3-5 days (No. 2-6), and the geomagnetic field have no time to recover. Two last small sporadic storms were not isolated too: the storm No. 8 began 40 hours after the storm No. 7. At polar latitudes it is observed higher activity during each of storms, and AE-index reaches the maximum values more than 1300 nT on March 11 whereas in quiet time it's values are 30-80 nT.

Results and discussion

The cardiovascular system state for group of 17 volunteers during March 01 to April 29, 2011 is investigated. In the present work a symmetry coefficient of a T-wave of the electrocardiogram (further – the electrocardiogram parameter T) was chosen as a parameter of investigation. The value or amplitude of a teeth of an electrocardiogram is one of the main indicators which are using for the interpretation of the electrocardiogram [9]. The type of a teeth and intervals between them depends on alternate of excitement and relaxation phases of a cardiac muscle. Teeth appears and grows at those moments when any myocardium parts are working, but another one are in the rest. The tooth T most often shows on various disturbances in a cardiac muscle state. More detail one can see this methodic of measurements of parameter T in works [4, 5].

Measurements were carried out in two conditions – in the rest and after physical activity. Averaged by a method of epoch composition values of parameter T are shown on Figure 2 for all group of examinees – for a quiet condition (a) and after physical and emotional activity (b).

a)

b)

Fig. 2. Histogram of averaged by a method of epoch composition values of parameter characterizing cardiovascular system state (parameter T, a symmetry coefficient of a T-wave of the electrocardiogram) – for a quiet condition (a) and after physical and emotional activity (b).

For a quiet condition six increases of parameter T with maxima on March 4, 13, and 22 and on April 1, 10 and 19 are separated on the histogram. The first two increases are connected with the moderate isolated storms on March 1 and 10 – after the beginning of a storm parameter T begin to increase and reach the maximum at third day of a magnetic storm. During a small sporadic storm No. 3 the maximum of parameter T is observed in day of the storm beginning – on April 1. It is possible to consider in this case parameter T reaches maximum at third day after the beginning of geomagnetic activity increasing because its growth can be connected with positive splash of Dst-index as far as 35 nT on March 29.

During the time of three nonisolated storms on April 6, 8 and 11 one can see the growth of parameter T, and this growth is much more considerable previous one though the storm intensity was smaller. May be this is an evidence that in the case of storms follow one after another the magnetic storm effect can accumulated in a human being. During the time of two small storms on April 18 and 19 one can see the same behavior – the value of parameter T increase is comparable with the increase during moderate storms in March.

One would think, the third parameter T increase with the maximum on March 22 isn't connected with a storm. Amplitude of Dst-index fluctuations was less than 20 nT, and that isn't storm-time. It is necessary here to take into account behavior AE-index which increase evidences the substorm activity growth in polar latitudes. It is known that usually substorm activity increases during storm-time and this show Fig. 1. The substorms appear also means tha geomagnetic activity growth at high latitude region and this reflected in a human being. Since March 20 AE-index begins

to increase, its values exceed 300 nT, and on March 23 substorm activity reaches almost 600 nT. Perhaps the increase of parameter T on March 22nd are caused by this type of geomagnetic disturbance – the substorm.

The parameter T behavior after the loading have some differs. First, we see any not six but only four increases. Secondly, all of them have less value, than in a quiet condition. It is necessary to note parameter T have no response on a storm No. 1, March 1. It could have an explanation if a sporadic storm didn't acts on examinees after loading. However two last storms also were sporadic. Take into attention that the fourth parameter T increase began on April 6 and, gradually increasing, reached a first maximum on April 9, and absolute maximum on April 18. Therefore it is logical to explain this parameter T increase as effect of accumulation on three recurrent storms following one after another on April 6, 8 and 11. Therefore, and in this case during two sporadic storms examinees under loading didn't feel any effects on April 18 and 19.

Conclusions

The parameter T characterizing a cardiovascular system state of the of volunteers in Yakutsk city - the symmetry coefficient of T-wave of the electrocardiogram - during the March-April 2011 showed a clear dependence on geomagnetic conditions - namely, the rise during geomagnetic storms

2. On average, the growth of parameter T begins with the beginning of a geomagnetic storm and reaches a maximum at the third day of the storm.

3. More precisely, ' this dependence appears during the periods of storms of recurrent type

4. After loading dependence on geomagnetic activity appears less clear

5. Not all of the 17 subjects equally show a dependence on geomagnetic factors: part reacts significantly and their amplitude change varies several times, and for the other changes consist of some percents.

To clarify these preliminary conclusions require further research on a larger statistical material.

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