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Geomagnetic, cardiovascular and geo-cardiovascular congruences of cycles: putative co-periodisms

Abstract. A sense for magnetism in humans and more broadly for nonphotic solar effects is not consciously perceived, even though the cosmos may have broad biospheric consequences. Associations are already documented for the human circulation and for mental and cellular functions with geo- and interplanetary magnetism. We compare interval estimates of periods in view of the ever-present uncertainties, congruence assess corresponding periods by the presence or absence of overlap between the CIs (95% confidence intervals) of the paired periods, found by the nonlinearly extended cosinors in time series of geomagnetic indices, Kp, quasi-logarithmic local index of the 3-hourly range, its derivatives Cp and C9, on the one hand and on the other hand in separate data sets of systolic (S) and diastolic (D) blood pressure (BP) and heart rate (HR) of 360 patients, each monitored ambulatorily (ABPM) for 24 hrs. Some circasemiseptan periods are shared by SBP, DBP and HR in female patients and further by C9 and Cp. Kp reveals a period of 4.31 days, with an even longer period found for SBP in men in the spectral region examined, the periods being picked because of their statistical significance in that spectral region. The gender differences in HR and SBP have their precedents in other regions of the circasemiseptan spectrum of these variables. The circaseptan coperiodisms between geomagnetic indices, Kp, Cp, C9 and cardiovascular system (SBP, DBP) in periodicity is clear for women patients only. The coperiodisms of HR with 10.7 C in 21 days period, and the circaseptan coperiodism again only of Kp with the BP were found.

Key words: geomagnetic, cardiovascular, patients, chronobiology, 24-hour blood pressure monitoring (ABPM), coperiodism, variability of vascular anomalies, variability of vascular disorders.

Introduction

Congruence or similarity in characteristics such as the period or phase of a spectral component in two or more concomitantly sampled time series of the same variables or of different variables within intracellular entities, cells, tissues, organs, organ systems, individuals, populations with spectral temporal characteristics of oscillations environmental factors such as space weather, ranging from infradians,multiples or submultiples of the week over transyears or trans- and cis-half-years to decadesis of undoubted scientific and practical interest, for example, for predicting an increase in the number of infectious diseases, or exacerbations of cardiovascular diseases and other non-communicable diseases [1-4].

Wobbly nature of some natural physical environmental and biospherical spectral components require an inferential statistical approach, e.g., according to Marquardt [5;6]. The congruence of anticipated components can be meaningfully assessed to approximate a yet-to-be-developed test of H_0: periodτ_1 (e.g., environmental τ) = τ_2 (e.g., biological τ) [= … = τ_k (e.g., sociological τ)], or the already available test at a fixed τ of $H_0 : \varphi_1 = \varphi_2$ [= … = φ_k] [7].

The overlap of CIs of the periodin two or more time series being compared by the cosinor [5; 6; 8] extended by Marquardt's algorithm [9] is the criterion for congruence. The same comparison also defines similarity and dissimilarity, the latter referred to as acongruence when the periods are separated by more than the length of a $\tau$with its CI, admittedly an

arbitrary definition, to be refined as more data accumulate [10]. The search for congruence and similarity among periods based on CIs realizes that the changes in many physiological and geomagnetic variables are in part aeolian, i.e. nonstationary cycles that wax and wane in amplitude, A, to the point of disappearance and reappearance, that drift in period, sometimes bi- and trifurcating, and drift in phase, φ. These cycles are nonstationary in time and in space [11, 12].

Environmental about half-weekly periods are likely harmonics of the sun's rotation around its axis at the solar equator and influence geomagnetic indices like Kp. A likely double tidal contribution and its harmonics are difficult to separate, although this has been attempted in a newborn studied around the clock for 27 months [2]. Other harmonics are circadiseptans, described by Hermann Fritz in 1888, as an ~13.8-day cycle and by Franz Halberg [10]. With a different (selective) assortment, circaseptans have been found in an individual, in the form of congruent periods of blood pressure and heart rate with periods in the solar wind and/or the geomagnetic indices aa, Kp and/or Dst [13]. The biospheric circaseptans were damped but persisted in the absence of circaseptans in the area of sunspots [14]. Thus, a link between the sun and the earth's magnetism, and our heart and circulation was rendered extremely likely at multiseptan frequencies [10].

Non-photic solar effects in humans are not consciously perceived, that is, "felt", even though space may have wide biospheric implications [15; 10]. Associations are already documented for the human circulation and for mental and cellular functions with geo- and interplanetary magnetism [16-19]. Emphasis was placed on the study of shared frequencies or their reciprocals, the periods, period. Rather than looking for the same point estimates of period in paired nonstationary wobbly oscillations, we compare interval estimates of periods in view of the ever-present uncertainties. Consequently, congruence is a way to assess corresponding periods by the presence or absence of overlap between the CIs (95% confidence intervals) of the paired periods, found by the non-linearly extended cosinors in time series of geomagnetic indices, C9, Cp and Kp on the one hand and on the other hand in separate data sets of SBP (systolic blood pressure), DBP (diastolic blood pressure) and HR (heart rate) of treated cardiac patients, each monitored ambulatorily. Widely known researches studied the effect of the solar magnetic cycles of solar activity and magnetic storms on various aspects of human life, physiological parameters, and including cardiovascular system

[13, 14, 17, 19]. Also are known geographical differences associated with superposition of geomagnetic and heliomagnetic fields, that local, specific for each of the geographical areas [3, 4]. Almaty in this aspect is a specific region, located in the foothills and earthquake-prone area, the population of this largest metropolis in Central Asia undergoes a more pronounced influence of the solar magnetic storms and the effect of the geomagnetic field more pronounced in connection with the periodic seismic activity, but we didn't found research related geomagnetic influence to cardiovascular diseases in this region.

Materials and methods

We performed this retrospective forward observational study in the "Smart health university city" Kazakh National university, Almaty, Kazakhstan from January 2018 to December 2019. We consecutively recruited patients older than 18 years patients with diagnosed hypertension after treatment. In total, 360 patients (167M +193F) were enrolled in this study. The TM-2430 monitor from A&D (Japan), BPLab monitor from OOO Petr Telegin (Russia) was used to measure BP and HR.

Averages per 24 hrs of HR and S or DBP were assigned to the calendar date of the monitoring and spectra of each time series as a whole (globally in time) were separately computed for men and women and for each variable. Mean values assigned to the date of monitoring were assembled irrespective of age into two separate series by gender. Basic congruences were subsequently sought and found among the series of the mean values of each of the individuals and each of the variables in each set, and further between the paired periods of geomagnetic and organismic time series, with focus on the about half-weekly (circasemiseptan) spectral region. A combination of linear and nonlinear cosinor methods [5, 6, 8, 9] served for temporally global analyses (of a time series as a whole). Plexograms, complemented by analyses of variance of the stacked data visualized signals detected by cosinor spectra [5, 6, 8]. For each series data were analyzed by sphygmochron [6], consisting of parametric and non-parametric assessments. Parametrically, by least squares (Figure 1), a two-component model, consisting of cosine curves with anticipated periods of 24 and 12 hours, is fitted to the data (Figure 2) yielding estimates of the ME-SOR (*M*, Midline Estimating Statistic Of Rhythm), 24-hour and 12-hour double amplitudes (2A) and acrophases (φ) [6].

The study was done after clearance from the local bioethical committee of the Al-Farabi Kazakh National University, IRB00010790, protocol No. IRB-A080) and consent was taken from all subjects.

Results and discussion

Non-parametrically, percentage time elevation, area of excess and timing of largest excess are determined by numerical integration. In addition to MESOR-hypertension, deviations from these chronobiological norms lead to diagnoses of CHAT (Circadian Hyper-Amplitude Tension) and/or ecphasia when the 24-hr BP-2A is excessive and/or the 24-hr BP- φ is outside acceptable limits but the 24-hr HR- φ is acceptable. These conditions along with an excessive pulse pressure (above 60 mmHg) and a deficient HR variability (standard deviation of HR <7.5 beats/min) constitute Vascular Variability Anomalies (VVAs) when present during one or a few days, or Vascular Variability Disorders (VVDs) when the abnormalities are confirmed over repeated week-long records in the absence of a persisting load [20]. Any two or more coexisting VVDs are referred to as Vascular Variability Syndromes (VVSs).

The figure 1 shows that after treatment, arterial hypertension, with which all patients were referred, remained in 27% of patients, in a small part, mainly women, the SBP mesor (2.5%) and the DBP MESOR (6.4%) fell even below the normocoridor, almost one third of patients (28.3%) had bradycardia, 22% of patients had no VVA, whereas 50% had multiple VVAs, Figure 1. CHAT of SBP and DBP, deficient heart rate variability, etc. were found, each of which increases the likelihood of complications of cardiovascular diseases, up to lethal [20].

The performed spectral analysis of the aggregate ABPM data and fluctuations in geomagnetic activity in the same time period revealed a number of periodicities up to month. Some circasemiseptan periods are shared by SBP, DBP and HR in female patients and further by C9 and Cp. Kp reveals a period of 4.31 days, with an even longer period found for SBP in men in the spectral region examined, the periods being picked because of their statistical significance in that spectral region. The gender differences in HR and SBP have their precedents in other regions of the circasemiseptan spectrum of these variables.

The circaseptan coperiodisms between geomagnetic indices, Kp, Cp, C9 and cardiovascular system (SBP, DBP) in periodicity is clear for women patients only, see Table 1. The coperiodisms of HR with 10.7 C in 21 days period, and the circaseptan coperiodism again only of Kp with the BP were found.
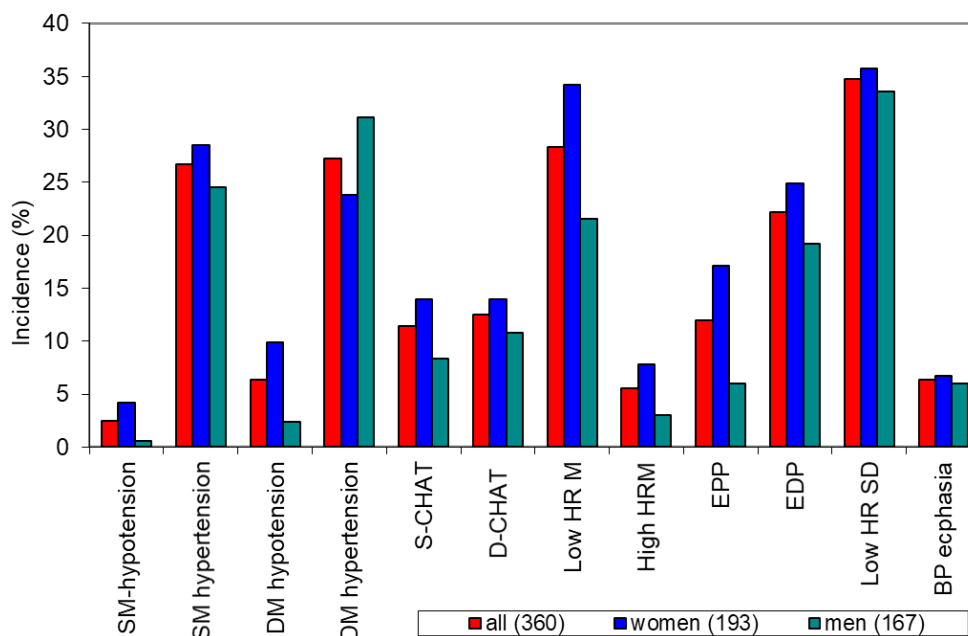

Figure 1– Incidence of VVAs in about 24-hr ABPM records
obtained in routine hospital practice during consecutive two years
SM – SBP MESOR, DM – DBP MESOR, S-CHAT – Circadian Hyper-Amplitude-Tension (CHAT) of SBP,
D-CHAT – CHAT of DBP, EPP – Excessive pulse pressure,
EDP – Excessive double product, SD – standard deviation

Table 1 – Coperiodism geomagnetis and cardiovascular indices in circaseptan-monthly range

	SBP		DBP		HR		Kp	Ap	Cp	C9	10.7C
	men	women	men	women	men	women					
Period, days	7.9*; 9.1*	7*; 21*	9.1*	7*	14.4*; 21*	6.4*; 21*	7*; 14*	8.7**; 13.65*	14*	14*	15.6*; 21*

Note: *p<0.05; **p<0.001

However, acrophases in this circaseptan rhytms are not in same phase time, vascular answer time is differ with geomagnetic acrophases time for about 2-3 days. Earlier in the literature, the "anticipatory response" of heart rate, blood pressure and other physiological parameters has already been described, which can occur 2–3 days before the onset of magnetic storms [21]. This anticipatory effect was first discovered by Chizhevsky in the 1920s, and suggested that some unknown solar radiation was responsible for this [22, 23]. The increased radiation caused by coronal ejections reaches the Earth in 8 minutes, while the increased density and speed of the solar wind takes several days to reach the Earth's magnetosphere, resulting in a magnetic storm [21].

21-days period in HR, male and female patients both correlates to 10.7C geomagnetic indices. The dispersion of the acrophase time lies within the same range. Sex differences had been noted earlier in the circadian MESOR and circadian double amplitude of heart rate variability in the range of seconds and minutes. Moreover, an about 2-week cycle in the ECG was detected for heart rate only in women (not in men) [24].
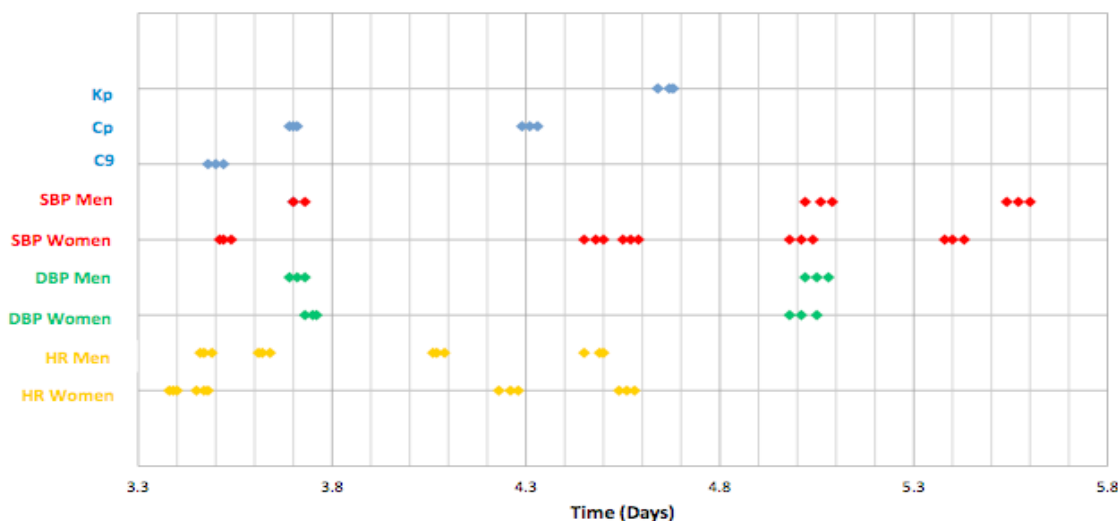

Figure 2 –Circasemiseptan coperiodism between geomagnetics indices (Kp, C9 & Cp) and the human circulation. Periods – in days, abscissa.

Figure 2 shows differences among variables and further differences between genders, as well as among the geomagnetic indices, which is consistent with previous studies [25]. Some circasemiseptan periods are shared by SBP, DBP and HR in female patients and further by C9 and Cp. Kp reveals a period of 4.31 days, with an even longer period found for SBP in men in the spectral region examined, the pe-

riods being picked because of their statistical significance in that spectral region. The gender differences in HR and SBP are also present in other regions of the circasemiseptan spectrum of these variables [21; 24].

Analysis of cardiovascular monitoring data for geomagnetic and other coperiodisms will be important to rule out chance contributing to congruence, once more than the 6 pooled time series examined herein on a few hundred patients become available on much larger data sets. Beyond establishing the degree of generality of congruences, one could try, notably on longer series, to implement a remove-and-replace approach [10; 25]. The relative merits of various helio- and geomagnetic indices, other than those here studied, could then also be examined in the light of biological coperiodisms, assuming that sooner or later a remove-and-replace or at least a subtract-and-add approach has found biospheric consequences, associated with changes with a geomagnetic coperiodism. In Figure 2, C9 and Cp seem to be closer to the human circulation than Kp.

Monitoring the environment by self-measurement of blood pressure on a population basis has already served to detect the after-effect of the Japanese earthquake and tsunami in Sendai in 2011 [26]. Staff measurements in Ladakh, Kashmir, India, have detected the paradecadal solar cycle's signature primarily in the systolic blood pressure of men and diastolic blood pressure of women, again on a population basis [26]. Ambulatory blood pressure measurements on a relatively small group of 11 subjects found an increase in systolic blood pressure for 2 days before the Sendai earthquake and tsunami [28]. The concomitant geomagnetic and cardiovascular monitoring may contribute to understanding cataclysms of societal health, including military and political affairs, that carry signatures of the sun in the decadal spectral range [10]. Coperiodisms in the circasemiseptan range involve a much shorter turn-around time for interpretation and are particularly pertinent to neonatology, when the infradians (near the circadians) dominate in the spectrum. Furthermore, in this range, by several methods, an association with the human heart has been validated by cross-spectral coherence with both geo- and interplanetary magnetism [10].

Conclusion

Some circasemiseptan periods are shared by SBP, DBP and HR in female patients and further by C9 and Cp. Kp reveals a period of 4.31 days, with an even longer period found for SBP in men

in the spectral region examined, the periods being picked because of their statistical significance in that spectral region. The coperiodisms of HR with 10.7 C in 21 days period, and the circaseptan coperiodism again only of Kp with the BP were found. The circaseptan 7-days rhythms were significant in BP women' variable only, and in geomagnetic indices, for Kp, acrophases in this circaseptan rhytms are not in same phase time, vascular answer time differs with geomagnetic acrophases time for about 2-3 days. Such "anticipatory response" of blood pressure may contribute to work with bioindication of cataclysms.

Acknowledgment

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