ARTERIAL PRESSURE BIORHYTHMS IN CLINICALLY HEALTHY MIDDLE-AGED MALES AND RHYTHMS OF SOLAR ACTIVITY

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Blood pressure (BP) is a self-regulated parameter of the circulatory system, in which the basic role in self-regulation is ascribed to interaction between two contours: intrasystemic and neurohumoral regulation [7]. However, besides systems of BP regulation that lie within the body, a regulating effect of external factors on this process can also be postulated and, in particular, an effect of changes in solar activity on the BP rhythm.

This paper describes an attempt to discover the way in which rhythms of solar activity can influence BP biorhythms of different frequencies in the male populations of Moscow and Leningrad, in order to find criteria for long-term prediction of the tendency of change in BP and discovery of the optimal times for implementing preventive measures, aimed at reducing the risk of development of ischemic heart disease in men of the most productive working age (40-59 years).

EXPERIMENTAL METHOD

The investigation made use of the results of an epidemiologic study conducted simultaneously in Moscow and Leningrad from March, 1975, through July, 1977 (the time of the minimum of the 11-year cycle of solar activity), within the program of Soviet–American collaboration on Problem No. 1: "The pathogenesis of atherosclerosis." The investigation was conducted on randomly selected males born in 1916-1935, who lived at the beginning of the investigation in the October District of Moscow and the Petrograd District of St. Petersburg. Of the total number of persons selected in Moscow 3908 (77.7%) men, and in Leningrad 3907 (78.1%) men were studied. The investigation was carried out by highly standardized techniques, and details of the program and organization of the investigations were described previously [6, 15]. Systolic (SBP) and diastolic (DBP) blood pressure were measured by means of a standard sphygmomanometer and an instrument with floating zero, so that any displacement of the measuring instrument toward a result obtained previously could be eliminated. Measurements were made twice, with each instrument in turn. In accordance with the program, testing was carried out virtually every day (with intervals for weekends and holidays). In order to discover latent biorhythms in the time course of BP, in accordance with the requirements of the mathematical model [11] average weekly weighted results of BP measurement with the floating zero were used as input data. Thus each of the 119 points on the graph showing the time course of BP represents the average of testing of about 65 persons during concrete weeks. The Wolf (sunspot) numbers (products of the number, area, and intensity of sunspots), an integral characteristic of solar activity against the background of which the men

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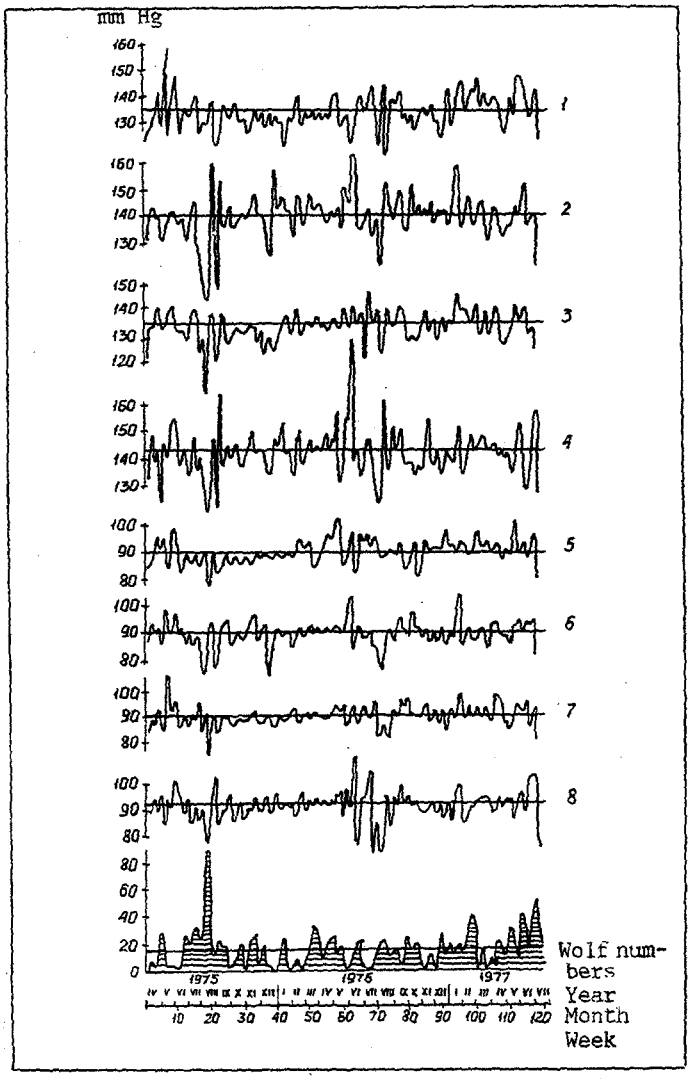

Fig. 1. Natural time course of systolic (SBP) and diastolic (DBP) blood pressure in healthy middle-aged men and time course of solar activity (SA): 1) SBP (inhabitants of Moscow), 2) SBP (inhabitants of St. Petersburg), 3) SBP (men aged 40-49 years), 4) SBP (men aged 50-59 years), 5) DBP (inhabitants of Moscow), 6) DBP (inhabitants of St. Petersburg), 7) DBP (men aged 40-49 years), 8) DBP (men aged 50-59 years). Abscissa) years, months, and weeks of investigation; ordinate) blood pressure (mm Hg) and Wolf numbers (conventional units).

were tested, also were grouped into averaged weekly data, from the time course of which the rhythms of solar activity with different frequencies were identified with reference to the same mathematical model [11]. According to the method in [11], each biorhythm and heliorhythm discovered was studied for the degree of its difference from noise, and only those rhythms which differed from noise with a level of significance of $p > 0.05$ were chosen for examination. Biorhythms of BP and heliorhythms (SA), revealed by the weekly data, were tested for significance by superposing the aggregated rhythms on the initial databanks by the method of multiple regression. The phase stability of the

biorhythms was tested by extrapolation of phases of rhythms of the same frequency, and recognized from two independent halves of the BP rhythm studied.

EXPERIMENTAL RESULTS

To study the effect of the geographic place of residence, and also of the age of the subjects tested on their geographic place of residence, all the data were presented in the form of four groups: 1) inhabitants of Moscow, 2) inhabitants of St. Petersburg, 3) inhabitants of both cities between the ages of 40 and 49 years, and 4) the same, between the ages of 50 and 59 years.

The natural average weekly time course of SBP and DBP for all groups studied, and also the time course of the Wolf numbers, measured synchronously with the investigations, are illustrated in Fig. 1.

It will be clear from Fig. 1 that each of the curves has a complex individual course. However, even on visual examination it will be clear that the sharp rise of solar activity in the summer of 1975 is synchronous with considerable disturbances in the time course of BP of all the groups of men tested. A less marked increase in the intensity of the oscillations of BP was observed against the background of increases of solar activity in the winter and summer of 1977. Against the background of the extremely low SA in the spring and summer of 1976 greater disturbances of the oscillations of BP were observed.

Considering the independence of the measurements of BP in Moscow and Leningrad, and also the independence of Wolf numbers synchronous with BP, a visual examination of the graphs of these parameters (Fig. 1) reveals: 1) the absence of a regular pattern of changes in SA within the year (month by month during the year) and, at the same time, the absence of a regular pattern in BP changes within the year; 2) dependence of spontaneous fluctuations of BP in healthy middle-aged men on spontaneous rises of SA. These contradictory conclusions lead directly to the suggestion that hitherto unknown dimensions of biorhythms of BP and SA exist, with periods of under or over 1 year, whose presence may perhaps determine the resonance association between spontaneous fluctuations of BP and rhythms of solar activity.

On the basis of these first conclusions the task of the subsequent investigation was reduced to finding the principles governing fluctuations of BP and of solar activity through the detection and analysis of parameters of BP biorhythms and rhythms of SA with unknown (not preassigned) periods.

Any process can be represented as the sum of the corresponding sinusoidal curves. Individual sinusoids under these circumstances can provide more meaningful information leading to the discovery of the essence of the process than the total curve, reflecting the integral dynamics of the chosen parameter [1] (a clear example of this last statement was given by the cardiogram and its components). Taking account of the laws of summation of oscillations, in our approach to the discovery of latent biorhythms and of heliorhythms with unknown periods, we foresaw the need to find the fullest possible set of rhythms, not multiples of each other, in the time course of the processes studied. This approach differs in principle from the traditional methods of discovery of biorhythms [2, 3], which do not allow the parameters and significance of the rhythms characterizing the process studied to be judged [14].

On the basis of Fourier's theorem and supplementing it with the complex procedure of "searching" for individual lengths of periods, phases, and amplitudes of the rhythms and assessment of their difference from "noise" [11], from the natural weekly dynamics of BP in each of the groups of men tested and from the natural dynamics of the Wolf numbers we selected sets of individual cosinusoidal oscillations ($p \leq 0.05$), each of which simulates a separate biorhythm or heliorhythm and can be described by the equation:

$$X_t = G + A \cdot \cos(2\pi \cdot t/T - \varphi),$$

where X_t is the value of the parameter on the given day of investigation, G the mean value of the parameter, A the amplitude of oscillations around the mean level, φ the phase (the angle of shift of the cosinusoid, showing the position of the first maximum on the time scale), T the period of the oscillations, and t the days of investigation.

The dynamics of SBP and DBP in the four groups of men studied is made of up to 23 dimensions of biorhythms within the range from 2.2 years to 2 weeks. In the absence of statistically significant differences in the lengths of the periods of the different dimensions of biorhythms, each dynamics of SBP and DBP clearly possesses an individual set of the total number of rhythms detected; biorhythms of the same frequency may also differ in different groups in their amplitudes and phases.

With stricter selection of meaningful biorhythms by analysis of their correlation, not with the weekly, but with the daily dynamics of BP, some of the dimensions of the biorhythms found can be excluded, for they disappear at once in all groups of SBP and DBP (2 years, 8 months, 3 months), whereas some dimensions of biorhythms disappear only within each concrete group. After selection, the following biorhythms were found to be most meaningful for judging oscillations of BP in middle-aged men: periods of 5 months, 1 year, 30 weeks, 10 weeks, and 2 months.

Despite differences in the age and place of residence of the men studied the total biorhythmologic structure of the change in SBP and DBP in all the groups was not random, for it copied the set of rhythms of SA. Within the limits of each dimension of rhythms, oscillations of SBP and DBP were usually closely similar in phase (in-phase oscillations), but for rhythms with a period of 10 months, 3 months, 10 weeks, and 3.5 weeks a sharp difference was found in the phase of the biorhythms in the groups of men studied. In most cases a definite tendency was found for the rhythms of BP and solar activity to be out of phase. However, biorhythms of BP with periods of 5 months, 2 months, 7 weeks, and 5 weeks do not conform to this rule, for they were almost in phase with the corresponding rhythms of the Wolf numbers. On the whole, the diversity of the phase relations of the biorhythms and heliorhythms discovered accounts for the complexity of the course of oscillations of BP and Wolf numbers (Fig. 1) and the irregularity of appearance of rises and falls of these parameters month by month during the different years of the study.

The frequency analogy of BP biorhythms and SA rhythms which we have found provides practical confirmation of Chizhevskii's hypothesis [9], which postulates global dependence of the course of biological processes on the rhythm of change of solar activity. However, differences in phases and amplitudes of the BP biorhythms and SA rhythms which we found show that the heliobiological relationships are dissimilar and very complex because of the different degrees of involvement of each dimension of heliorhythms in the control of the BP biorhythms of corresponding frequency.

Lengths of the periods of some BP biorhythms and heliorhythms are quite unexpected (for example, 155 days, 70 days, and so on), for they do not coincide with, and even are not multiples of known periods of revolution of the earth around the sun and rotation of the sun and earth around their own axis. If, however, biorhythms of BP and SA are compared with the wave periods of the planets of the solar system (calculated in [8]), we see that they coincide in the duration of the period. We found similar frequency coincidences previously for annual biorhythms of peripheral blood leukocytes and erythrocytes of healthy individuals [4, 5], and also for monthly and seasonal biorhythms of the blood serum cholesterol of healthy rabbits [10]. This may indicate that not only the sun's energy and gravitation affect motion and energy of the planets of the solar system, but the planets themselves, by their relative position and wave characteristics, affect energy processes taking place on the sun, and in that way, the annual and monthly complex of blood biorhythms of man and animals. Duplication of the spectrum of rhythms of SA by the frequencies of the planets of the solar system thus connects biological clocks oriented toward solar activity with the whole complex of cosmic rhythms, confirming Vernadskii's idea of the cosmic origin of life and of the indissoluble unity of the laws of living and nonliving matter. The mechanism enabling living organisms to respond resonantly to rhythms of SA of different frequencies is described in [12, 13].

To utilize the parameters of the BP biorhythms we have found, and in particular, phase relations of biorhythms and heliorhythms of the same frequency, in order to attempt to find a test for long-term prediction of the tendency of the change in BP in healthy middle-aged men, it was necessary to study the stability of phase coordination between biorhythms of SBP and DBP and rhythms of SA. For this purpose, the databanks of BP and Wolf numbers investigated were divided into two parts (March, 1975 to June, 1976, and April, 1976 to July, 1977), and in

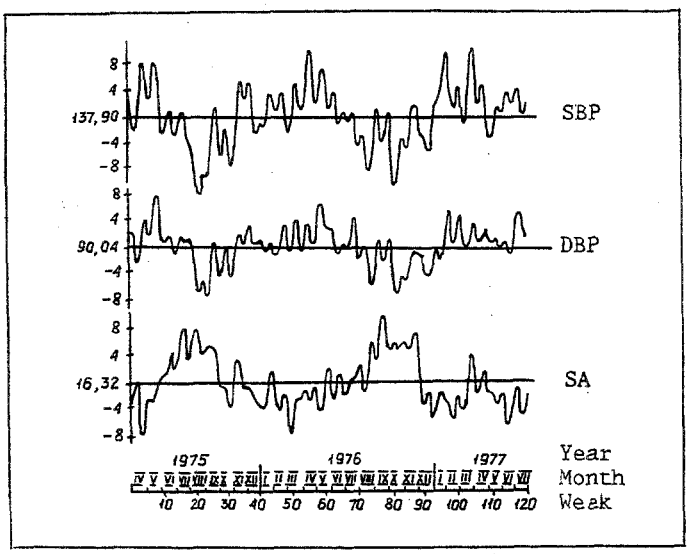

Fig. 2. Theoretical dynamics of sum of rhythms of SBP, DBP, and SA of the same frequency, and with stable phase throughout the period of investigation. 1) SBP, 2) DBP, 3) SA. Abscissa) weeks, months, and years of investigation; ordinate) amplitude of oscillations of parameters around mean level (legend as to Fig. 1).

each part of these banks, using the same mathematical method [11], latent biorhythms and heliorhythms whose phase could be mutually extrapolated to both halves of the independently tested data, were found. After analysis in this way, eight dimensions of rhythms were found to be stable with respect to phase relations between rhythms of BP and SA: 1.2 year, 1 year, 30 weeks, 5 months, 10 weeks, 2 months, 1 month, and 3.5 weeks.

Theoretical time courses of SBP, DBP, and SA, obtained by summation of eight harmonics with stable phase, the parameters of which were found by averaging G, T, A, and φ in all groups of men tested, are shown in Fig. 2. By comparing the theoretical curves in Fig. 2 it is possible to draw conclusions regarding the annual dynamics of changes in blood pressure of healthy middle-aged men against the background of the phase of an at least 11-year cycle of solar activity:

1. The annual dynamics of SA has a significant effect on the annual dynamics of SBP and DBP of the men tested.

2. An increase in solar activity leads in general to activation of the internal systems of the body, lowering the blood pressure of healthy men.

3. The system of BP regulation in the subjects tested is linked by resonance, not with all the rhythms of SA discovered, but predominantly with only those heliorhythms which, for a period of 2.5 years, were in stable phase coordination with rhythms of SBP and DBP.

4. Abrupt rises or falls of solar activity lead to an increase in the range of oscillations of blood pressure in all groups of men (spring–summer of 1975, summer of 1977 in Fig. 1). However, since not all heliorhythms are connected by resonance with the working of systems controlling BP in healthy men, widening of the range of oscillations may be observed in the natural annual dynamics of SBP and DBP against the background of the "quiet" dynamics of solar activity (summer of 1976 in Fig. 1). In the last case, the integral peak of resonance frequencies of SA (Fig. 2) is "masked" in the natural dynamics (Fig. 1) by superposition of other heliorhythms discovered, not connected with regulation of BP oscillations, on it.

5. The dynamics of SBP and DBP in Fig. 2 represents an integral tendency for the change in blood pressure in healthy middle-aged males during the period of time investigated.

6. The technology of long-term prediction of fluctuations of blood pressure or of other biological parameters [4, 5, 11, 14] with respect to the sum of the current phases of rhythms of solar activity requires preliminary establishment of resonance rhythms of SA characteristic of the parameter tested, which is essential for the plotting of scientifically based graphs of measures of mass prophylaxis.

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