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Relation of the Regular Gravitational Field Variations to Biochemical Processes Observed *In Vitro* and *In Vivo*

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Abstract—Studies carried out at the Arctic and Antarctic Research Institute revealed some relationships between the dynamics of biochemical reactions and the λ_D function, which describes regular variations of the gravitational field under the combined influence of the Sun and the Moon. The rate of unithiol oxidation *in vitro*, concentration of thiol compounds in human urine, and some hematological indices (erythrocyte sedimentation rate, hemoglobin content) were examined with the λ_D function. Compatibility of the biochemical indices and λ_D function is indicative of an essential influence of regular variations of the gravitational field on the rhythm of biochemical processes. The λ_D function is not related to lunar phases (new moons and full moons) and, therefore, cannot be associated with tidal effects.

Key words: biochemical reactions, rythmic fluctuations, solar activity, lunar phases

INTRODUCTION

A link between the biosphere and space environment through electromagnetic fields was shown previously [1]. At the same time, the Earth is constantly affected by a regularly changing gravitational field, and these gravitational field variations, caused by the Sun and the Moon, seem to have a powerful influence on many rhythmic biochemical processes. Studies carried out in AARI revealed obvious relationships between changes in the uneven headway and rotary motions of the Earth and dynamics of some biochemical reactions. The rate of the unithiol oxidation *in vitro*, concentration of thiol compounds in human urine, erythrocyte sedimentation rate, and hemoglobin content are good examples of indices apparently affected by variations in the gravitational field. Such measurements are compared with the behavior of the λ_D function [2], which characterizes the uneven rotary motion of the Earth.

RESULTS

Effects of Gravitational Influence on Rotary Motion of the Earth

The Earth rotary motion is uneven, since the combined gravitational influence of the Sun and the Moon varies while the Earth is moving along its orbit. As a result, the Earth axis of rotation moves relative to the celestial pole along a complex curve due to the combined gravitational influence of the Sun and the Moon. This complex motion can be reduced to the precession (secular) period of about 26 thousand years and nutation periods of several days to 18.6 years (see [2]). The short-term nutation motions (with a period less than 90 days) are taken into account by the equation for geocentric ecliptic longitude of the Moon, where the main input is provided by three terms with periods of 14.8 days (variation), 31.8 days (evection) and 182.6 days (yearly inequality). The join effect of these main nutational movements is described by a λ_D function. The method for calculating the λ_D function, expressed in degrees, is described in the preceding paper [2]. The behavior of various biochemical processes is examined in comparison with the behavior of the λ_D function, which describes the deviations of the Earth axis relative to the celestial pole.

Unithiol Oxidation Rate

The unithiol test [3] was used as an index of the rate of biochemical reactions. The test is based on the determination of the rate of unithiol (sodium dimercaptopropane sulfonate) oxidation by sodium nitrite. Thiol compounds, including the reactive sulfhydryl (SH) groups, can participate in many chemical reactions. Redox reactions of thiol compounds are of large

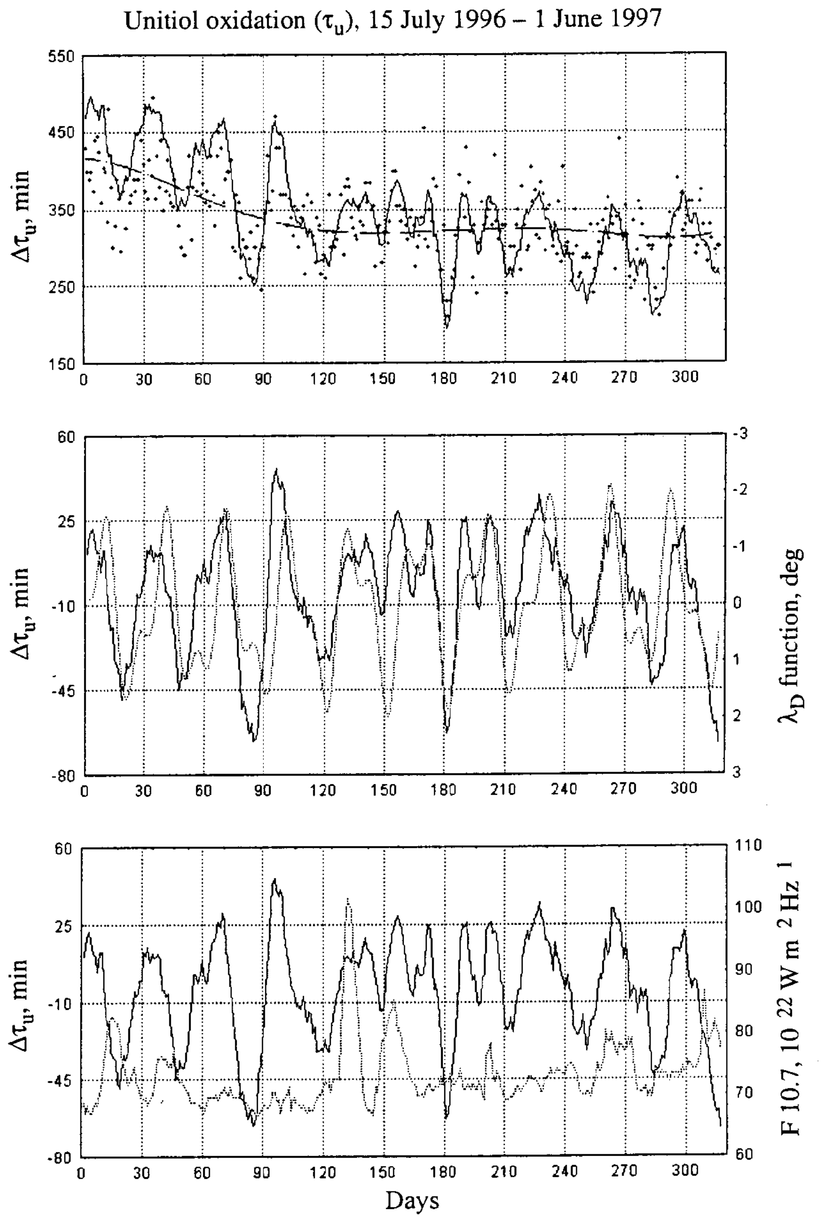

Fig. 1. (a) Distribution of the daily τ_u values (points) along with the 9-day means of τ_u (solid line), and the long-period trend in the course of τ_u obtained by a polynomial smoothing of the fifth order (dashed line) for period of 1996-1997; (b) deviation $\Delta\tau_u$ (solid line) in comparison with λ_D function (dotted line); (c) deviation $\Delta\tau_u$ (solid line) in comparison with the flux of solar radio emission F 10.7, taken as an index of solar activity.

importance in biology, since they ensure various vital functions in living organisms such as cell division, biological rhythm regulation, membrane permeability, enzymatic activity, antioxidant system function, etc. Thus, the unithiol test can be regarded as a suitable test to study the *in vitro* influence of gelio/geophysical factors on living organisms, even though the nature of the influence may remain unknown.

The experiment described in [4] has been timed to a period of the minimum of solar activity (from July 15, 1996 to June 1, 1997 when the monthly mean Wolf numbers did not exceed 18.5) to reduce the electromagnetic effects to a minimal level. Observations of the unithiol oxidation rate τ_u have been carried out at the polar station Mirny in the pristine environment of the Antarctic. Solutions of unithiol and sodium nitrite prepared in aqueous phosphate buffer (pH 7.0) were mixed so that the final concentrations of the reactants were $5 \cdot 10^{-4}$ and 10^{-3} M, respectively. The mixture was incubated in an thermostat at $t = 39°C$. Every 30 min, the residual amount of sulfhydril

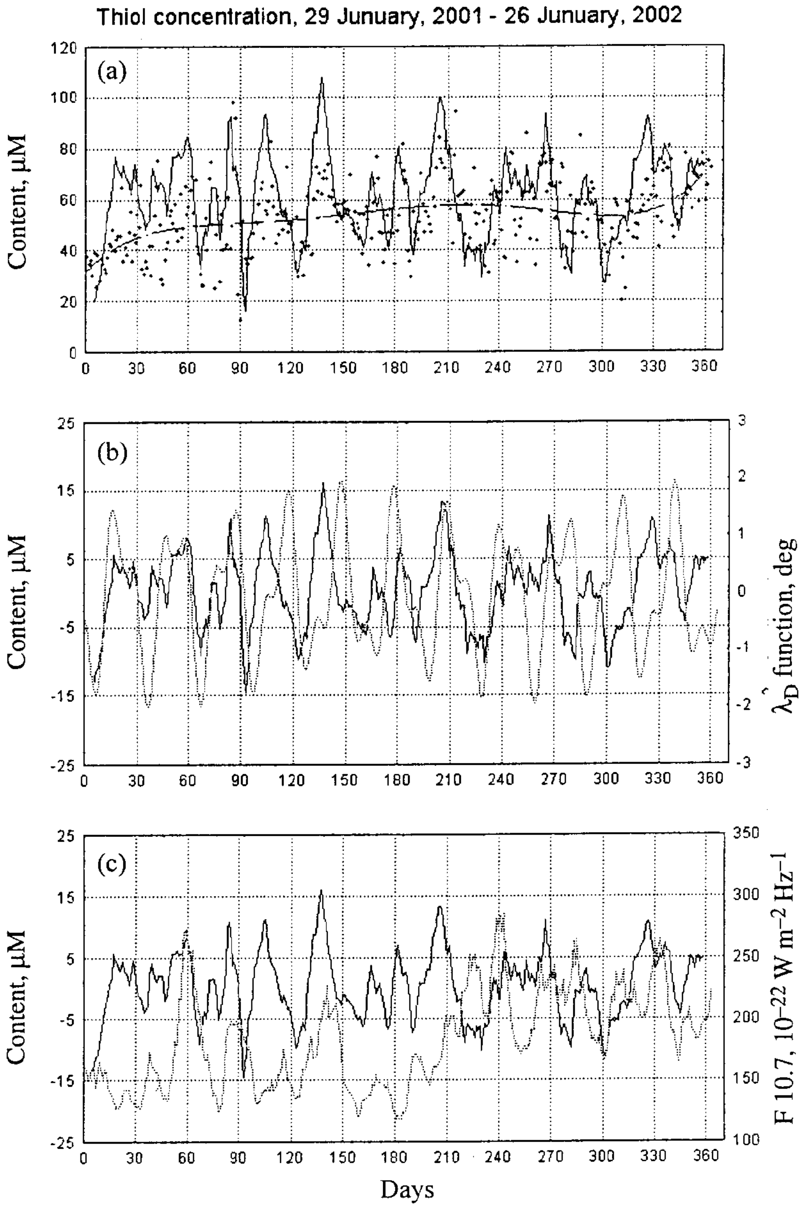

Fig. 2. Daily values of the thiol concentration in human urine (a) in comparison with the λ_D function (b) and the flux of solar radio emission F 10.7 (c) from January 29, 2001 to January 26, 2002.

groups in the incubation mixture was measured by a photocolorimetric method and expressed as a percentage, after which the difference between the initial and the current values was calculated, to give the measure of oxidized SH groups. The time required for oxidation of 50% of sulfhydryl groups, or the unithiol half-oxidation time τ_u, was determined graphically, and this value was used as an index of the reaction rate. 380 batches of measurements were performed over 320 days.

The nearly year-long measurements of daily τ_u values obtained by Gorshkov *et al.* [4] are shown in Fig. 1a along with the 9-day means of τ_u (solid line), and the long-period trend in the course of τ_u obtained by polynomial smoothing of order 5 (dotted line). The short-term variation of the oxidation rate ($\Delta\tau_U$) was derived as residuals between the 9-day means and the polynomial smoothing curve. Variations of the unithiol oxidation rate ($\Delta\tau_U$) are shown in Fig. 1 (solid line) along with the λ_D function for the period 1996–1997 (dashed line). The short-term changes in $\Delta\tau_u$ are subject to rhythmic fluctuations, which are similar to those of the λ_D function. A certain inconsistency is observed occasionally between these two curves and it may be

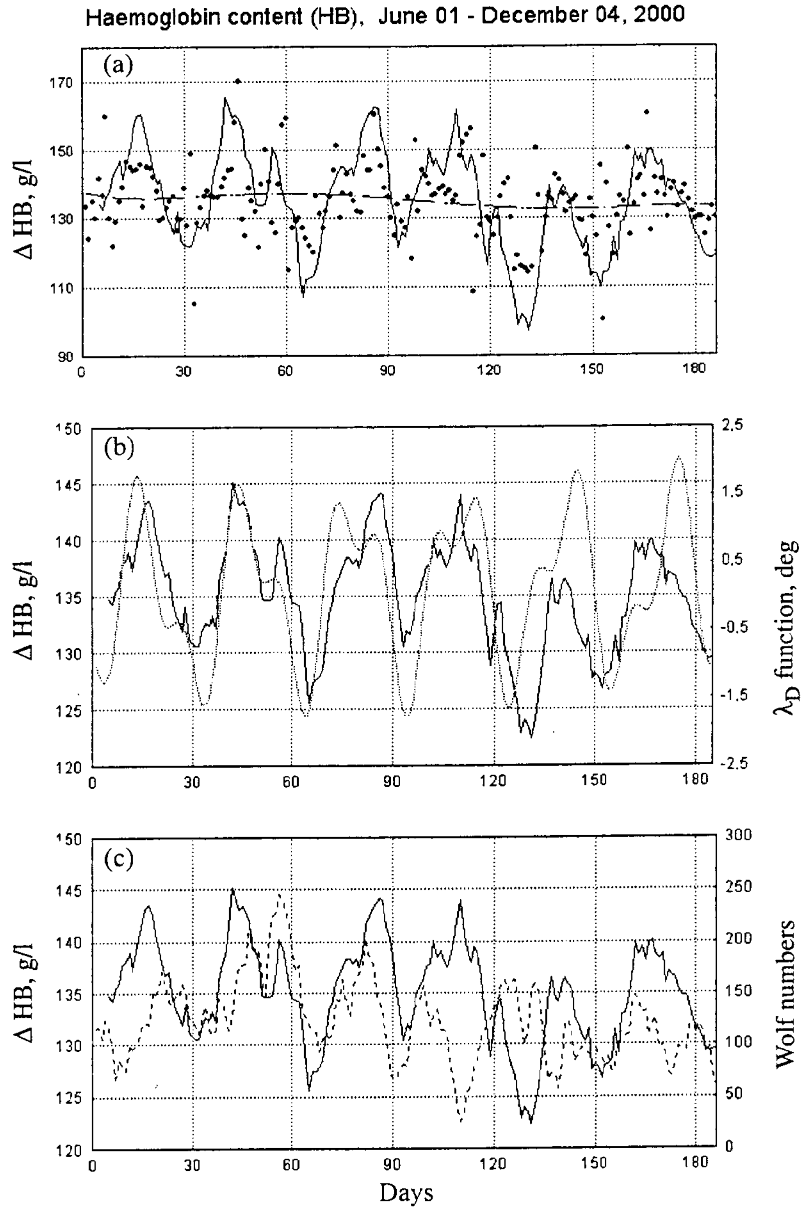

Fig. 3. Daily values of hemoglobin contept (a) in comparison with the λ_D function (b) and the Wolf numbers (c) from June 1, 2000 to October 31, 2000.

attributed to a failure to include the effects of non-uniform orbital motion of the Earth into the λ_D function. Figure 1 shows variations of $\Delta\tau_U$ in comparison with the flux of solar radio emission at 10.7 cm, taken as an index of solar activity. It is obvious that the unithiol oxidation rate varies irrespective of solar activity under conditions of minimum solar activity.

Variations of Thiol Concentration in Human Urine

The content of thiol compounds in daily samples of human urine was determined over the course of 12 months. The experiment was done by one of participants of the Russian Antarctic expedition at the Antarctic station Vostok under almost invariant living conditions. The daily routine at the station was the same throughout the year, the diet was fixed, and the liquid consumption was limited to water and juices. The weather conditions are among the most stable on the planet and yet extremely rigorous. Thiol concentration was determined by the Ellman method for each portion of fresh urine, with simultaneous measuring of its volume. More than 2800 samples were drawn for the period from January 29, 2001 to January 26, 2002. The thiol concentration per one liter of daily

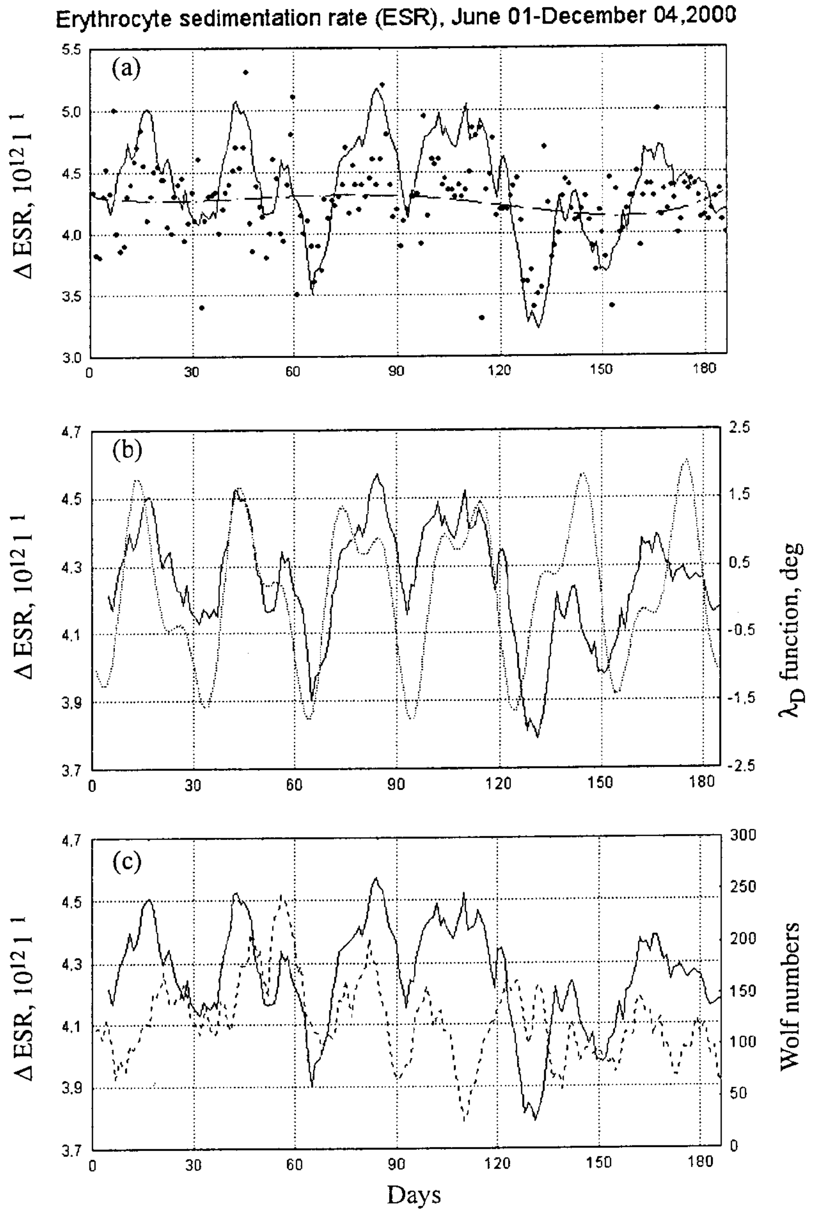

Fig. 4. Daily values of the erythrocyte sedimentation rate (a) in comparison with the λ_D function (b) and the Wolf numbers (c) from June 1, 2000 to October 31, 2000.

urine (in mcM/l) was estimated as well as the total daily amounts of thiol compounds extracted from the body. The method and detailed description of the experiment are published in this issue [6].

To separate the short-term variations of thiol concentration, the 9-day means have been calculated (solid line in Figure 2a), and the long-period trend was derived by polynomial smoothing of order 5 (dashed line) in the same manner as for the unithiol oxidation rate. The short-term variation of the thiol concentration has been estimated in residuals between the 9-day means and the curve of the polynomial smoothing. Figures 2b and 2c show changes of the thiol concentration (solid line) during the year in comparison with the λ_D function (dotted line) and with the flux of solar radio emission F 10.7 (dashed line). The daily values of the thiol concentration in the human urine are subject to rhythmic fluctuations, which resemble the λ_D function more closely than the data on solar activity.

Undeniably, the agreement of the gravitational field variations with the thiol contents in the human urine was not as clear as with variations of τ_u. It is possible that here the effect of solar activity played a

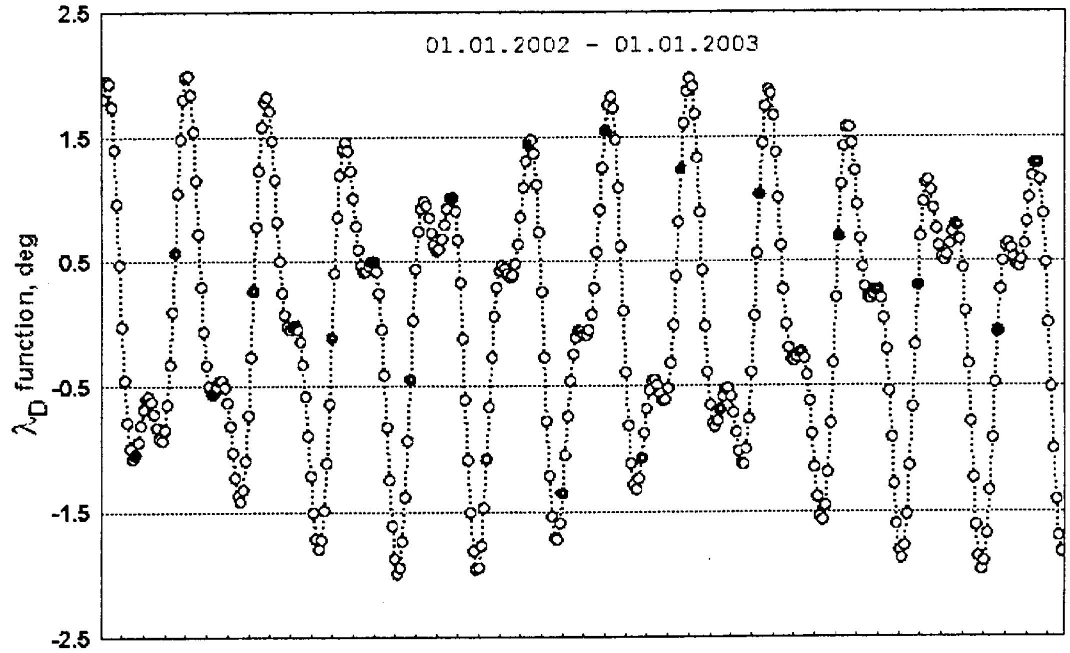

Fig. 5. Distribution of days with a new moon (empty circles) and a full moon (filled circles) on the curve of the λ_D function for the year 2002.

major role since the flux of solar radio emission F 10.7 in 2002 was nearly twice that in 1996. Nevertheless, we think that other external psychological and physiological factors were more influential, such as the weather conditions at the Vostok station and the light regime (alternation of polar day and polar night). Thus the 170th day (June 22) corresponds to the polar midnight; the time range from 220th to 250th day is the coldest time at Vostok (with temperatures as low as –75°?); and 270th to 330th day is the time of transition from a completely dark night to a completely light day. In other words, some biological human factor could also affect the thiol status in the human body.

Human Hematological Indices

The pronounced relationship between the rhythmic fluctuations of daily values of the unithiol oxidation rate and variations of the gravitational field suggests that the latter may affect the redox state of cells and tissues in live organisms and thereby modify the redox-dependent regulatory mechanisms controlling many biological processes. Among such processes are the mechanisms of adaptation of an organism to environmental stress factors, which enhance free radical oxidation and elicit a response of the antioxidant defense system of the organism [2]. We chose to analyze the results of hematological tests widely used in mass screening programs. Patients with chronic diseases exhibit high sensitivity to the so-called heliophysical factors. Therefore, analysis of peripheral blood specimens was performed among patients with chronic diseases of the cardiovascular, digestive, and nervous systems. The erythrocyte sedimentation rate (ESR) and hemoglobin content (HB) were determined [7] daily on weekdays for patients admitted to the District Military Hospital No. 442 and Peter the Great General Hospital in St. Petersburg (Russia) in period from June 1, 2000 to October 31, 2000. Specimens were drawn from a total of 2500 patients, about 15–20 specimens per day.

The mean daily values of HB and ESR are shown in Figs. 3 and 4, respectively, along with the 9-day mean (solid line) and the long-period trend obtained by the polynomial smoothing of the fifth order (dashed line). The short-term variations of the HB and ESR parameters derived as residuals between the 9-day means of the HB and ESR values and curve of the polynomial smoothing are shown by solid lines in Figs. 3b and 4b. The values of the HB and ESR are subjected to rhythmic short-term changes that are correlated with the λ_D function for the same period (dotted line). A comparison between hematological indices (solid line) and solar activity (dashed line) is given in Figs. 3c and 4c, where solar activity is represented by Wolf numbers characterizing the abundance of active regions on the Sun. One can see that hematological indices are in a much better accordance with the λ_D function than with solar activity.

DISCUSSION

Results of our analysis show that the rhythmic fluctuations are typical of various biochemical processes. These fluctuations are compatible with the λ_D function, which represents the superposition of the main nutational oscillations (with periods of 14.8, 31.8, and 182.6 days) that occur under the influence of combined gravitational fields of the Sun and the Moon. The λ_D function shows the best fit to the oxidation rate of the unithiol *in vitro*. Indices of biochemical processes in human organism (concentration of thiol compounds in the human urine, hematological indices) do not show such a perfect fit to the λ_D function, but the rhythm of the processes remains intact. These results indicate that there must be some other external factors that affect the human mental and physical state.

Changes in solar activity are usually regarded as one of the main factors affecting the biosphere. Our analysis does not confirm this point of view. Indeed, a 27-day periodicity characterizes the solar activity, in contrast to the ~32-day periodicity typical of the nutational oscillations and fluctuations of the biochemical indices. As a consequence of the difference in the main period of variations, the changes of solar activity and biochemical indices can apparently be in phase for no longer than two months, after that the phases change and no longer coincide. This regularity is obvious for years of maximal solar activity (2000), when the 27-day recurrence of the solar spots was clearly pronounced (see Figs. 3 and 4).

The λ_D function is not associated with the lunar phases (new moon and full moon stages) and, therefore, is not related to tidal effects. Figure 5 shows the days with a new moon and a full moon (filled circles) on the curve of the λ_D function for 2002. One can see that both new- and full-moon days can fall on maxima as well as on minima of the λ_D function. If lunar phases also influence biochemical reactions, the rate of biochemical reactions should depend on a joint action of lunar phases and variations of the gravitational field described by the λ_D function.

CONCLUSIONS

Rhythmic fluctuations with periods of approximately 14.8 and 31.8 days are typical of various physicochemical and biological processes in nature.

These fluctuations are consistent with the λ_D function that describes the short-term nutational motion of the Earth under the joint action of the Sun and the Moon.

Variations of the gravitational field appear to influence the rhythms of physicochemical and biological processes occurring on Earth.

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