

Investigation of Solar about 5-Month Cycle in Human Circulating Melatonin: Signature of Weather in Extraterrestrial Space?

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Abstract. Melatonin, produced mainly in the pineal and the gut, is often thought of as the "dark hormone" as its concentration in the circulation is high during darkness and low during light in diurnally- and nocturnally-active mammals in health. About-daily and about-yearly periodicities can thus be anticipated to characterize melatonin, matching the two major photic environmental cycles. Non-photic solar influences have also been observed, melatonin being depressed in association with magnetic storms. While less stable than the daily and yearly changes, non-photic solar dynamics also undergo various periodicities. Among them is an about 0.42-year (about 5-month or 154-day) cycle, reported by several physicists in relation to Zürich relative sunspot numbers and to solar flares. This putative signature of solar activity was found in the incidence pattern of sudden cardiac death in Minnesota, USA, among other geographic locations. A cycle with a period of about 0.42 year is here reported in data on circulating melatonin of 172 patients studied between Oct 1992 and Dec 1995 in Florence, Italy. Melatonin may mediate some of the Sun's effects upon the biosphere in certain frequency-windows such as a cis-half-year of about 5 months.

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Introduction

In monthly means of Zürich relative sunspot numbers, Wolff reported an about 154.3-day periodicity [1]. A similar component had been reported by Rieger et al. to characterize the occurrence of hard solar flares [2]. Many subsequent publications [e.g., 3-11] corroborated the about 154-day cycle and qualified its presence as being intermittent, a lingering doubt about its reality remaining in some physicists' minds.

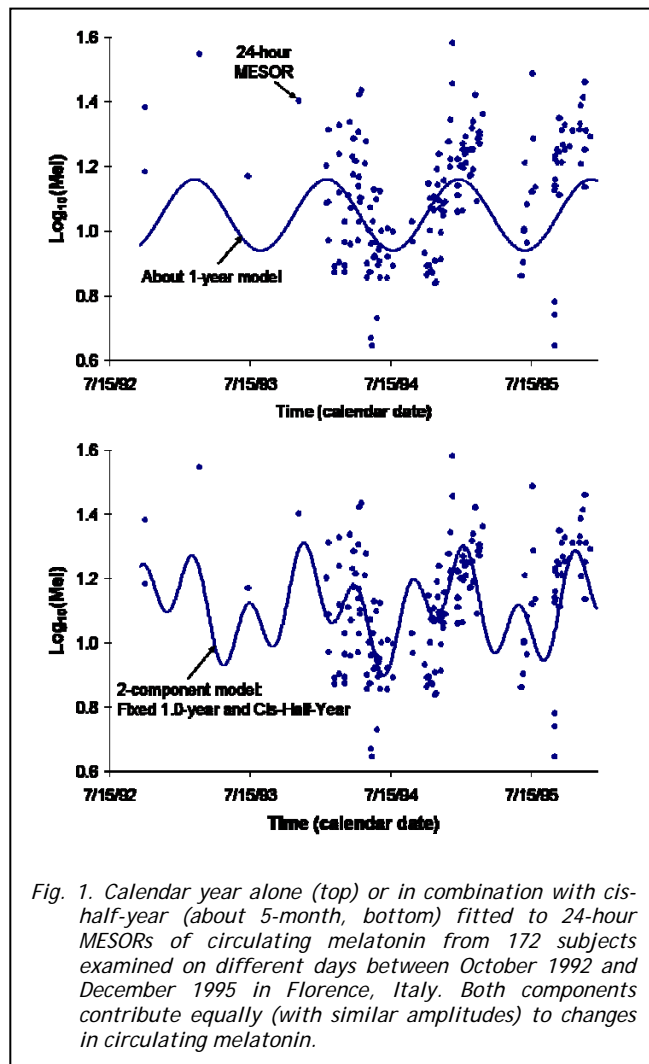
A putative signature of this cycle characterizing solar activity was found in the incidence pattern of sudden human cardiac death in Minnesota, USA, among other geographic locations [12, 13]. We here report on an about 0.42-year cycle in data on circulating melatonin from 172 patients studied between October 1992 and December 1995 in Florence, Italy, previously investigated from the viewpoint of yearly and half-yearly components [14, 15].

Melatonin excretion has been related to exposure to artificial magnetic fields [16] and to magnetic storms in the Arctic [17]. In the laboratory, a response of the circadian melatonin rhythm to a magnetic storm has also been ascertained *in situ* in the pineal and in the hypothalamus sampled at six different circadian stages for 7 consecutive days [18]. Melatonin may mediate some of the sun's frequency-window-dependent effects upon the biosphere.

Materials and Methods

The study involves data on circulating melatonin from 40 men, mean age 48.33 ± 2.25 years, and 132 women, mean age 48.26 ± 1.47 years, in Florence, Italy (43.47°N , 11.15°E), sampled between October 1992 and December 1995. An earlier report of this study [14] focused on the precise calendar year and half-year only. New evidence of cycles differing from precisely half a year in solar as well as in biological data

prompted complementary analyses summarized herein.



Melatonin was determined by radioimmunoassay in samples collected from each subject at 4-hour intervals for 24 hours. The data were log₁₀-transformed to normalize their distribution. Each subject's data were analyzed by cosinor (least squares fit of a 24-hour cosine curve to the data) to obtain estimates of the rhythm-adjusted mean (MESOR, Midline Estimating Statistic Of Rhythm) and of the 24-hour amplitude and acrophase (phase of maximum by reference to local midnight) [19-21]. Individual MESORs and 24-hour amplitudes as well as each of the six time-specified values were pooled across all subjects to form longitudinal series spanning about 3 years. The latter were spectrally analyzed to determine components contributing most to the overall variance.

Results

As reported earlier [14], circulating melatonin showed a large-amplitude statistically significant

circadian rhythm peaking in the middle of the daily dark span. MESORs were found to follow a yearly variation with a trough in May and June (P<0.001), corresponding to a peak in the 24-hour amplitudes that also showed a yearly cycle (P=0.007). For the six time series of circulating melatonin at different clock-hours (04:00, 08:00, 12:00, 16:00, 20:00 and 00:00), each analyzed separately, a yearly variation with a trough in May/June could be documented (P<0.001) in the four series from samples collected between 08:00 and 20:00, but not in data from 00:00 (P=0.46) or from 04:00 (P=0.86). A 0.5-year component was found to account for a larger proportion of the overall variance at these two circadian stages, reaching statistical significance (P=0.007) by vectorial averaging across the six timepoints [14]. Accordingly, these results were included in a chart of 0.5-year components starting the mapping of multi-frequency cycles in the biosphere and the cosmos [15].

Since earlier analyses had focused only on annual and semi-annual components, and since evidence had accumulated in the interim for the existence of components with periods slightly longer or shorter than the year and/or half-year in a number of helio-geomagnetic indices as well as in some biological data, new analyses were carried out to assess the broader spectral structure of circulating melatonin in the pooled data from the 172 subjects. The about-yearly component was found to contribute most to the overall variance for the series of circadian MESORs, and for samples collected at 08:00, 12:00, 16:00, and 20:00. The 95% confidence intervals (CIs) for the circannual period of these series covered exactly 1 year and the corresponding 95% CIs of the amplitude did not cover zero, attesting to the statistical significance of the circannual component. In addition, an about 0.4-year (cis-half-year) component was found to also characterize these endpoints as well as the series of 24-hour amplitudes and those of samples collected at 00:00 and 04:00, where it contributed most of the overall variance.

Table 1.
Nonlinear Results of Circulating Melatonin (172 subjects studied between November 1992 and December 1995):

Log₁₀-transformed data

Endpoint	Period (year)	[95% CI]	Amplitude (initial)	[95% CI]
Total Period = 1.0 year				
MESOR	0.94	[0.81 1.07]	0.11	[0.08 0.17]
24h-Amplitude	0.99	[0.76 1.22]	0.06	[0.00 0.09]
08:00	0.96	[0.86 1.11]	0.16	[0.08 0.24]
12:00	0.97	[0.81 1.14]	0.13	[0.04 0.22]
16:00	0.87	[0.74 1.00]	0.16	[0.05 0.29]
20:00	0.95	[0.83 1.07]	0.16	[0.08 0.27]
00:00	NS			
04:00	NS			
Total Period = 0.42 year				
↑ MESOR	0.360	0.172 0.498	0.11	[0.05 0.17]
↓ 24h-Amplitude	0.434	0.385 0.471	0.09	[0.01 0.11]
↓ 08:00	0.391	0.368 0.416	0.12	[0.04 0.21]
↓ 12:00	0.425	0.388 0.470	0.10	[0.02 0.18]
↓ 16:00	0.389	0.365 0.412	0.12	[0.03 0.20]
↓ 20:00	0.398	0.371 0.430	0.13	[0.03 0.22]
↑ 00:00	0.362	0.367 0.438	0.09	[0.00 0.17]
↑ 04:00	0.353	0.345 0.418	0.08	[0.00 0.16]

A model consisting of a fixed 1.0-year component alone or with an adjustable 0.42-year (cis-half-year) component fitted to the circadian MESORs is illustrated in Fig.1. The model also fitted the series from different clock-hours, except for the data at 00:00 and 04:00, when only the cis-half-year is validated statistically ($P < 0.05$). Nonlinearly, an about 0.4-year component is invariably documented for all endpoints considered, Table 1.

It seems pertinent that when a trial period of 0.5 year is used instead of 0.42 year, the nonlinearly estimated periods remain unchanged, except for the series consisting of blood samples collected around 00:00. In this case, an about 0.55-year component is detected, which corresponds to a slightly smaller spectral peak than the about 0.4-year peak. A 0.55-year period closely matches the 0.56-year spectral component reported by Charles L. Wolff (see his Fig.5 for solar activity gauged by Zürich numbers, complementing the 0.422-year component displayed in his Fig.4, both in reference [1]).

Discussion

We had proposed earlier that for each biological spectral component, one should look for a corresponding environmental counterpart, and vice versa [22]. The concept of congruence was introduced to that effect. It is based on a comparison of periods characterizing two or more time series (such as in a comparison of environmental and biological data). There is congruence when the 95% CIs of the respective periods are overlying or overlapping, as defined and illustrated in Fig. 2. As shown in Fig.3, there is congruence for the cis-half-year among all endpoints of circulating melatonin considered herein.

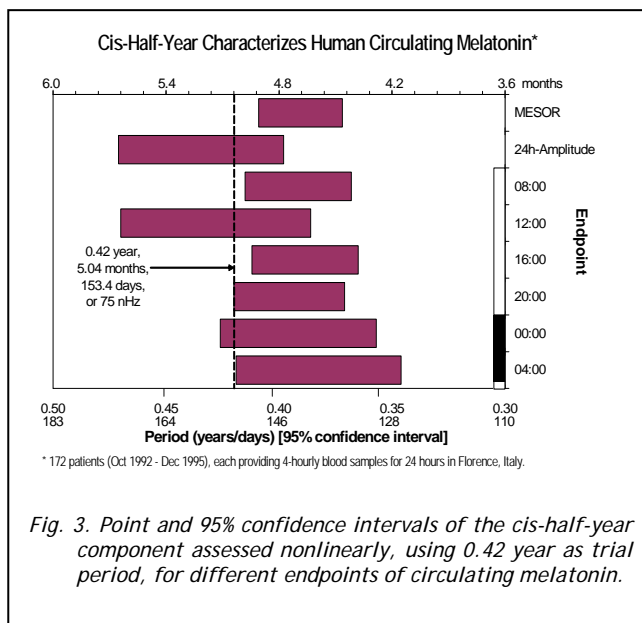


Fig. 3. Point and 95% confidence intervals of the cis-half-year component assessed nonlinearly, using 0.42 year as trial period, for different endpoints of circulating melatonin.

The finding of an about 0.4-year component in circulating melatonin similar to the 154-day periodicity reported by Wolff [1] for Zürich numbers and by Rieger et al. [2] for the 139 solar flares monitored by the gamma-ray spectrometer on the Solar Maximum Mission (SMM) satellite suggests that human physiopathology may be affected by non-photic as well as by photic solar influences. A 158-day component was also reported by Kiplinger et al. [9] based on 6,775 solar flares observed with the hard X-ray burst spectrometer (also on SMM), taking data gaps into account. A periodicity of 154.6 ± 0.6 days was further reported by Bai and Cliver [4] based on studies of a 14-year interval from January 1958 to December 1971 and a 5.5-year interval from February 1978 to August 1983. Among solar cycles 19, 20 and 21, these authors indicate that sunspot area consistently shows the periodicity, as do flares with IP protons, but not several other endpoints that were characterized by a near 154-day cycle in only one or two solar cycles examined.

Melatonin may thus be a possible mediator of an informational effect by non-photics, including particle emissions from the sun acting in part via geomagnetic disturbance and/or directly.

If so, melatonin is likely to be characterized by components that are signatures of both photic and non-photic solar dynamics [23]. The large-amplitude circadian rhythm of circulating melatonin and of the urinary excretion of its major metabolites then can be anticipated to be modulated by yearly (Table 1, top) and half-yearly cycles, as well as by a cis-half-year (Table 1, bottom) and perhaps also in some instances by an about 0.56-year component, among others. A

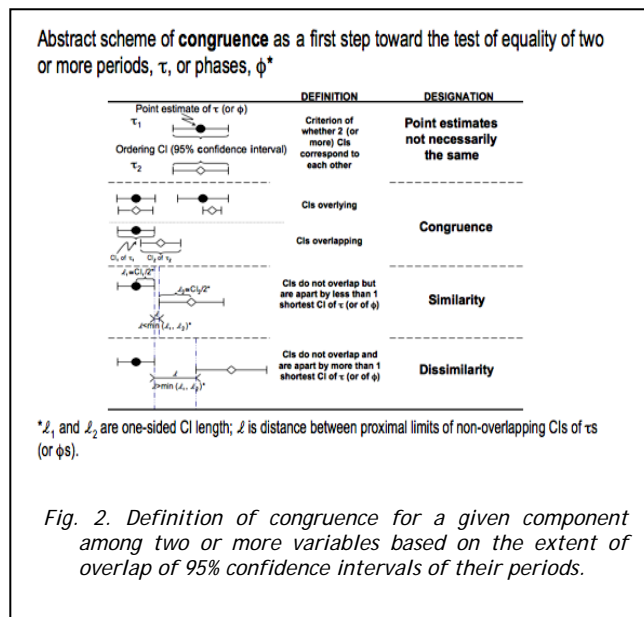


Fig. 2. Definition of congruence for a given component among two or more variables based on the extent of overlap of 95% confidence intervals of their periods.

rigorous assessment of the presence and/or relative prominence of near half-year (0.42-, 0.50-, and 0.56-year) components will require the collection of data over sufficiently long spans, so that these components with close periods can be resolved concomitantly, notably since changes as a function of solar activity cycle stage and/or from one solar cycle to another may also occur [4].

To achieve this goal, coding data for calendar date and clock hour will be essential, so that data obtained by different investigators using the same assay to determine melatonin may be pooled for analysis. The same assay was used to obtain the data analyzed herein, but the pooled data series analyzed stemmed from different subjects, including men and women 20 to 90 years of age. Similar data collected elsewhere under similar conditions could also be analyzed whether or not they were collected during a similar span.

Under the heading "Cyclomania", a book by Hoyt and Schatten [24] refers to "... a small, 154-day cycle [which] now exists in many solar phenomena". This statement can now be extended to physiopathology. Indeed, a cis-half-year has been documented in inferential statistical terms for suicide [25, 26; cf. 27, 28], sudden cardiac death [12, 13, 29-31], diastolic blood pressure [32], and the breakdown products of steroids, hormones essential for survival and reproduction [33]. The further statement by Hoyt and Schatten [24] that "To date we know of no attempt to find a meteorological response [to this about 154-day cycle]" may still be correct over a decade later, although, with caution, components with a period only slightly shorter than 0.42 year have been detected in wind direction and humidity data measured hourly for 8 years (from January 1998 to December 2005 at the Zugspitze/Hohenpeissenberg station in Germany [34]. Beyond climatology, the biospheric cis-half-year is also widely documented transdisciplinarily, as reviewed above.

Conclusion

According to the criterion of congruence, a cis-half-year in human circulating melatonin, perhaps genetically coded, validates the terrestrial biospheric or climatologic effects of an intermittent solar about 154-day cycle. The very intermittency of this cycle in solar activity should enable the further study of solar-biospheric relations by a remove-and-replace approach [35, 36], wherein the sun and/or earth implements a subtraction or removal of a component and its replacement. A cis-half-year was thus found to persist in the urinary excretion of steroidal hormone metabolites of a healthy man after this component could no longer be detected with statistical significance in geomagnetics [33].

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